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Engineering Library


# ENGINEERING:

## An Illustrated Weekly Journal.

*EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.*

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2.

VOL. CXII.—No. 2917.] *LONDON: FRIDAY, NOVEMBER 25, 1921.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.



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See Advertisement, pages 29 and 79, last week.
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And Auxiliary Machinery as supplied to the Admiralty. 2179

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See Illustrated Advertisement Page 100, Jan. 28.

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Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3551
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See page 17, Nov. 18. 9108

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**Tank Locomotives.**
Specification and Workmanship equal to Main Line Locomotives.
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See Advertisement page 75.

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High-class GUNMETAL STEAM FITTINGS.
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CARDIFF WAREHOUSE—132, BUTE ST.
BIRMINGHAM WAREHOUSE—NILE STREET, SHEEPSCOTE STREET.
See Advertisement, page 26. 9091

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London Office: 101, LEADENHALL ST., E.C. 3.
Works: BURNT MILL, near HARLOW, ESSEX.
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Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c. &c. 9604

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(ELECTRIC).
9036
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**The Mitchell Conveyor and**
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CONTRACTING ENGINEERS.
DESIGNERS and BUILDERS of all Classes of HANDLING MACHINERY.
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Telegrams: "Micontraco, Cent, London."
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Patent
**See's Hydro-Pneumatic Ash Ejector.**
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4835

**The Glasgow Railway Engineering Company.**
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**P. & W. MacLellan, Limited,**
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MANUFACTURERS OF RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION,
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 129, Trongate, GLASGOW. Od 8747
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**Yarrow Patent**
**Water-Tube Boilers.**
9564
Messrs. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
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THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3383

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LIMITED.
See Advertisement page 44, Nov. 18. 2402

**Taylor & Challen**
**Presses**
8195
About 200 NEW PRESSES in Stock in our Showrooms for immediate delivery at specially Reduced Prices.
TAYLOR & CHALLEN, LTD., Engineers, Constitution Hill, BIRMINGHAM.
See Full page Advertisement page 58, Nov. 11.

**Matthew Paul & Co., Ltd.**
LEVENFORD WORKS, **Dumbarton.** 9518
See Full Page Advt., page 72, Nov 11.

**WAYGOOD-OTIS**
**LIFTS.** 9455
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**Diesel Engines, Six Cylinder,**
two and four stroke, 850, 1000, 1200 H.P. Excellent condition. Dynamos for above 2·0 or 500 Volts, D.C. Immediate delivery and low price.
Also 2-500 Kw. PARSONS TURBINE SETS, 250 or 500 Volts D.C., with Condenser and spare armature.
ELECTRICALLY DRIVEN AIR COMPRESSORS, 250 Volts D.C. Pressures 1500 to 3000 lbs. per square inch.
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See Advt. page 94, Nov. 18
**Steam & Pneumatic Power Hammers**
**Drop Stamping Plant**
**B. & S. Massey, Ltd.,** 9140 MANCHESTER.

## The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by SIR WILLIAM FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 9310

## The Bucyrus Company,

EXCAVATING AND MINING MACHINERY MAKERS

of South Milwaukee, Wisconsin, U.S.A., and formerly represented in the British Isles by Messrs. G. F. West & Co., wish to announce that they have now Opened their Own Office at

19, IDDESLEIGH HOUSE, CAXTON STREET, WESTMINSTER,

and henceforth All Communications for them should be so addressed.

9741

## Correspondence Courses for

B.Sc., Inst. C.E., I. Mech. E., all ENGINEERING EXAMS. Special Courses and Single Subjects. Personal tuition.—For full particulars apply to MR. TREVOR W. PHILLIPS, B.Sc. (HONS.). Assoc.M.Inst.C.E., M.R.S.I., etc., 8-10, Trafford Chambers, 58, South John Street, Liverpool. 9286

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and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., M.B.E., A.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Thousands of successes during the last sixteen years. Courses may commence at any time.—39, Victoria St., Westminster, S.W. Tel. 4780 Victoria. 9814

## Inst. C.E. Exams.—Successes

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## Iron and Steel Institute.

28, Victoria Street, London, S.W. 1.

ANDREW CARNEGIE RESEARCH FUND.

The COUNCIL of the IRON AND STEEL INSTITUTE is PREPARED to RECEIVE APPLICATIONS for GRANTS in aid of research work on the metallurgy of iron and steel.

The number of grants in any one year is limited to five or six. The Council is not pledged to accept any particular application for assistance, but will give preference to those proposals which appear to them to be of the most practical advantage to the iron and steel and allied industries.

Proposals should be submitted before the end of February, 1922, on a special form to be obtained from the SECRETARY of the Institute. S 646


## TENDERS.

LONDON COUNTY COUNCIL.

## Tenders are Invited for the

SUPPLY of 1000 and alternatively 2000 TRAILING WHEEL TYRES for Electric Tramcars.

The Form of Tender may be obtained from the General Manager, London County Council Tramways, 23, Belvedere Road, Lambeth, S.E. 1.

No Tender received at the County Hall, Spring Gardens, S.W., after Twelve noon on Tuesday, 6th December, 1921, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk of the London County Council.
S 706

MIDLAND GREAT WESTERN RAILWAY OF IRELAND COMPANY,

OLD MATERIALS FOR SALE.

The Directors of the Midland Great Western Railway of Ireland Company are prepared to receive

## Tenders for the Purchase of

OLD MATERIALS.

Form of Tender, giving all particulars, can be obtained on application to the Storekeeper, General Stores Department, Broadstone Station, Dublin.

Tenders must be posted in time to be received at Broadstone on Monday, 5th December, 1921.

(By Order)
PERCY A. HAY,
Secretary.

Broadstone Station, Dublin,
19th November, 1921. S 672

THE ASSAM-BENGAL RAILWAY COMPANY, LIMITED, is prepared to receive

## Tenders for :—

COVERED GOODS WAGONS.

Specifications and Tender forms may be obtained at the offices of the Company, Bishopsgate House, 30, Bishopsgate, E.C. 2. A fee of £1 1s. is charged, which cannot under any circumstances be returned.

Drawings may be had at the cost of the tenderer, by application to Messrs. HONGRA, BENNETT & Co., Ltd., 78, Queen Victoria Street, E.C. 4.

Tenders must be delivered at the Company's Offices not later than noon on Wednesday, the 14th December, 1921.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
OSWALD I. MILNE, S 686
Secretary.

LONDON COUNTY COUNCIL.

## Tenders are Invited for Cen-

TRIFUGAL PUMPS and Oil or GAS ENGINES for Pumping Station to be erected at Hammersmith. The total pumping capacity of the station will be about 1,000 tons of water a minute.

Persons desiring to Tender may obtain, on and after Monday, 28th November, 1921, the Drawings, Specifications, Form of Tender, &c., on application to the Chief Engineer at the County Hall, Spring Gardens, Charing Cross, S.W., upon payment to the Cashier of the Council of the sum of £5. This amount will be returnable only if the tenderer shall have sent in a *bona fide* Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the Drawings, specification and other Contract Documents may be inspected, at the County Hall, before the payment of the fee.

No Tender received after Four p.m. on Monday, 9th January, 1922, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk of the London County Council. S 705

MANCHESTER CORPORATION GAS DEPARTMENT.

The Gas Committee are prepared to receive

## Tenders for the Supply,

Delivery and FIXING IN POSITION, of TWO ELECTRICALLY-DRIVEN CAPSTANS, and THREE DUMMY CAPSTANS, on the site at the Bradford Road Gas Works, Manchester.

Specification and Form of Tender may be had on application to Mr. GODFREY W. KAYE, Secretary, Gas Department, Town Hall, Manchester.

Drawings may be seen, permission to view the Site, and any other information obtained on application to Mr. W. NEWBIGGING, Engineer, at his Office, 5, Norfolk Street, Manchester.

Sealed Tenders in official envelope, addressed to the Chairman of the Gas Committee, and endorsed "Capstans, &c., Bradford Road Station," to be delivered at the Gas Offices, Town Hall, Manchester, not later than Nine a.m., on Wednesday, the 14th day of December, 1921.

The Gas Committee do not bind themselves to accept the lowest or any other Tender.

By Order,
THOMAS HUDSON,
Town Clerk.

Town Hall, Manchester.
November, 1921. S 701

EAST INDIAN RAILWAY.

The East Indian Railway Company is prepared to receive

## Tenders for the Supply and

DELIVERY of :—

LEATHER BUTTS, BUCKET, &c.,

as per Specification to be seen at the Company's Offices.

Tenders are to be sent to the undersigned, marked "Tender for Leather Butts, &c.," not later than Eleven o'clock a.m., on Wednesday, the 7th day of December proximo.

The Company reserves to itself the right to divide the order, also to decline any Tender without assigning a reason and does not bind itself to accept the lowest or any Tender.

For each Specification a fee of £1 1s. 0d. is charged, which cannot under any circumstances be returned.

By Order,
G. R. LILLIE,
Secretary.

Nicholas Lane, London, E.C. 4.
23rd November, 1921. S 721

THE BENGAL AND NORTH WESTERN RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

## Tenders for the Supply of :—

30 THIRD CLASS BOGIE CARRIAGES.
(without wheels and axles, &c.).

as per specification to be seen at the Company's Offices.

Tenders addressed to the undersigned, and marked "Tender for Carriages," are to be lodged not later than noon on Monday, the 19th day of December, 1921.

For each Specification a fee of £1 will be charged which cannot, under any circumstances, be returned.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
E. A. NEVILLE,
Managing Director.

237, Gresham House, Old Broad Street,
London, E.C. 2.
23rd November, 1921. S 719

METROPOLITAN WATER BOARD.

TENDERS FOR THE SUPPLY AND FIXING OF LANCASHIRE BOILERS, SUPERHEATER, PIPING AND FEED PUMPS AT DEPTFORD, S.E. 8.

The Metropolitan Water Board invite

## Tenders for the Supply and

fixing of Two Lancashire Boilers, Superheater, Piping, Feed Pumps, etc., at their Deptford Pumping Station, Brookmill Road, S.E. 8.

Forms of Tender, Conditions of Contract, Specification and Drawing may be inspected without payment of fee at the Offices of the Board (Room 184), Chief Engineer's Department, 173, Rosebery Avenue, Clerkenwell, E.C. 1, on and after Tuesday, December 6th, 1921.

Contractors desirous of tendering may obtain the necessary documents from Mr. HENRY H. STILGOE, M.Inst.C.E., the Chief Engineer, on production of an official receipt for the sum of £1 1s., which sum must be deposited with the Board's Accountant and will be returned on receipt of a *bona fide* Tender together with all incidental papers.

Such payments and applications must be made between the hours of Ten a.m. and Four p.m. Thursdays excepted (Saturdays Ten a.m. to Twelve noon).

Tenders, enclosed in sealed envelopes addressed to "The Clerk of the Board, Metropolitan Water Board, 173, Rosebery Avenue, E.C. 1," and endorsed "Tender for Boilers, Deptford," must be delivered at the Offices of the Board not later than Ten a.m. on Wednesday, 18th January, 1922.

W. MOON,
Clerk of the Board.

Offices of the Board,
173, Rosebery Avenue, E.C. 1.
November, 1921. S 681

THE COMMISSIONERS FOR THE PORT OF RANGOON.

60-TON FLOATING CRANE ON A SELF-PROPELLING PONTOON.

## Tenders are Invited for the

above PLANT, completely delivered, erected and ready for work in the Port of Rangoon.

Further particulars to be obtained from the Commissioners' London Agents, Messrs. OGILVY, GILLANDERS & COMPANY, Sun Court, 67, Cornhill, London, E.C. 3. S 718

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,
are prepared to receive

## Tenders for the Supply of:—

(1) ROLLING STOCK: 100 Broad Gauge Steel Covered Goods Wagon.

(2) SPRINGS: Laminated, Volute and Helical Springs, for the above wagons.

Specifications and Forms of Tender are available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked :—"Tender for Rolling Stock," or as the case may be, must be left with the undersigned not later than Noon on Wednesday, the 14th December, 1921.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 20/- for each copy of the Specifications, Nos. 1 and 2.

Copies of the Drawings may be obtained at the office of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W. 1.

W. B. REYNOLDS,
for Managing Director.

91, Petty France, S.W. 1.
23rd November, 1921. S 738

METROPOLITAN BOROUGH OF WOOLWICH.

ELECTRICITY DEPARTMENT.

DISPOSAL OF TINS REMOVED FROM HOUSE REFUSE.

The Council of the above Borough invite

## Offers for the Removal of the

whole of the TINS and OLD IRON, etc., collected from House Refuse, and now lying at the Plumstead Refuse Destructor Station, White Hart Road, Plumstead, S.E. 18.

The whole of the present deposit to be cleared within six weeks of acceptance of offer. The Council will also consider offers for periodical clearance in addition.

Offers should be endorsed "Removal of Tins," be sealed and addressed to the Borough Electrical Engineer, Town Hall, Woolwich, S.E. 18, not later than the 1st December next.

By Order,
ARTHUR B. BRYCESON,
Town Clerk.

Town Hall,
Woolwich, S.E. 18.
22nd November, 1921. S 711

SOUTH STAFFORDSHIRE WATERWORKS COMPANY.

TENDER for the LAYING of 18 in. and 24 in. STEEL PIPES, Somerford to Bloxwich.

The South Staffordshire Waterworks Company invite

## Tenders for the Laying and

JOINTING of about 16,000 lineal yards of STEEL WATER MAIN, 18 in. and 24 in. in diameter, from their intended Pumping Station at Somerford in the Parish of Brewood to Bloxwich, both in the County of Stafford, together with contingent works.

Forms of Tender, Specification, Bill of Quantities and Schedule may be obtained from, and Drawings inspected at the Offices of the Engineer-in-Chief, on and after November 21st, 1921, between the hours of 10 a.m. and 4 p.m. daily, Saturday excepted, upon the deposit of a cheque value Five Guineas, which will be returned on receipt of a bona-fide Tender, together with the return of all documents supplied.

Sealed Tenders, endorsed "Tender for Somerford—Bloxwich Main," must be delivered to the undersigned not later than Ten a.m. on Monday, December 12th, 1921. The Company do not bind themselves to accept the lowest or any Tender.

FRED J. DIXON, M.Inst.C.E.
Engineer-in-Chief.

20a, Paradise Street,
Birmingham.
November, 1921. S 619

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

## Tenders for the Supply of

the following STORES, namely :—

| | | Fee for Specification. |
|---|---|---|
| No. 1. | Steel Screw Couplings | £1 |
| No. 2. | Wicks Lubricating Pads, &c. | 10/- |
| No. 3. | Drawn Brass Angles, &c. | 7/6 |

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Steel Screw Couplings," or as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 6th December, 1921.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.

Company's Offices,
48, Copthall Avenue, E.C. 2.
London, 23rd November, 1921. S 720

## APPOINTMENTS OPEN.


## Jig and Tool Designer

REQUIRED for large Automobile Works. Give full particulars of previous experience and state salary expected.—Address, S 691, Offices of ENGINEERING.

UNIVERSITY OF LONDON, GOLDSMITHS' COLLEGE, NEW CROSS, S.E. 14.

## Applications are Invited for

the POST of PART-TIME LECTURER in Electrical Engineering (Grade—City & Guilds Final Examination). Remuneration in accordance with the London County Council's scale.

Applications should be made by letter, stating qualifications, to the WARDEN, Goldsmiths' College, New Cross, S.E. 14. S 655

ROYAL AIR FORCE.

CIVILIAN EDUCATIONAL STAFF.

## Required in January, 1922,

in connection with the next entry of Boy Mechanics, several ASSISTANT MASTERS for the Schools of Technical Training (Boys)—Halton, near Wendover, Buckinghamshire, and Cranwell, near Sleaford, Lincolnshire.

Candidates for these appointments must be graduates of a British University or hold equivalent qualifications. The principal divisions of the school curriculum are—(a) English, (b) Practical Mathematics, (c) Science (Applied Mechanics and Physics), (d) Mechanical Drawing.

The scale of pay (Grade III.) to which the full Civil Service bonus will be added is :—

Basic Scale.....£150—10—200—15—£350
Bonus for cost-of-living index figure ..... { minimum 183 17 6 / maximum 251 7 6
Total ..... { minimum 303 17 6 / maximum 601 7 6

The bonus as given above is calculated on the cost-of-living index figure of 130 and is subject to an increase or decrease of 1/26th for each rise or fall of five points in the index figure.

In fixing the rate of salary on first appointment as Assistant Master an allowance for previous experience of a suitable character may be made up to a maximum of 10 years (10 increments on the scale), and there will be a scheme of deferred pay in lieu of Pension.

Applications for appointment must be made on the appropriate form (A.M. 69), which can be obtained from the SECRETARY (A.E.), AIR MINISTRY, Kingsway, W.C.2. S 604

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The above post carries superannuation under a scheme similar to that of the Federated Universities.

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ASSISTANT, with ultimate promotion for department handling a specialty in non-corrodible metals. Good opportunity and prospects for energetic technically trained man. State experience and give references.—Address TECHNICAL, WM. PORTEOUS & Co., Advertising Agents, Glasgow. S 561

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MANAGER, for large Cement Works in India, qualified Engineer, with a complete knowledge of the manufacture of cement (wet process): three years' agreement, free unfurnished quarters.—Write, giving full particulars of experience and salary required to Z. S. 982., c/o DEACONS, Leadenhall Street, London. S 718

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experience and first-class references, to take position as Confidential Chief Clerk to head of large Engineering Company. Must be expert at shorthand and typewriting and up-to-date office organiser. Only first-class man need apply. Copies of references should accompany application.—Address, S 713, Offices of ENGINEERING.

## Wanted, a Time-Study Man

and RATE-FIXER. Applicant must be accustomed to taking accurate elementary time observations and to fixing rates for machining and erecting of parts for Prime Movers using Steam and Oil, in medium-sized Midland Engineering Works. American experience desirable. Give full details, experience, age, and salary required.—Address, S 710 Offices of ENGINEERING.

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Designing and manufacturing experience, REQUIRED in large Automobile Factory, to take charge under Planning Dept. Superintendent of all manufacturing operations. Preference will be given to those who have had previous experience of process setting.—Address, giving full details of experience and salary expected, S 693, Offices of ENGINEERING.

## THE EMPLOYMENT OF THE BLIND IN WORKSHOPS.

ONE has become accustomed to the idea that in machining metal parts eyesight is absolutely indispensable, and in as far as the quality and accuracy of the work depends upon the influence of the worker himself this is undoubtedly correct. The elimination of the personal element has, however, to a great extent been brought about by the employment of automatic machinery, which once properly adjusted, produces permanently pieces of uniform quality and finish. Not all kinds of parts required in mass production can, however, be made by automatic machines, and most machine tools require a constant supervision and regulation by the hand of the operator. A large number of machines, however, operate in such a manner, that the attendant has only to start the machine and to introduce the piece of work into it. He can thus in the main only influence the output, the working process being carried out independent from his influence.

The employment of the blind in machine work, which has recently been given a trial in some large industrial works in Germany and has proved entirely successful, has been made possible by the use of such automatic machines. The question of the employment of the blind is at present of great importance, because in all countries which took part in the war there are great numbers of blind who have to be cared for. In Germany the number of soldiers blinded in the war amounts to 3,122, as compared with 37,000 blind civilians. The information which follows and which deals with experience gained in Germany in the employment of the blind on machine work, is likely to be of interest and value in other countries, and may direct attention to possibilities which in some quarters have probably not been considered.

In the year 1916 Mr. Perls, a director of the Siemens-Schuckert Works at Siemensstadt, near Berlin, made experiments on the employment of the blind in the manufacture of small parts. Civilian blind were at first employed, in order to utilise the experiences gained with these in the subsequent training of blinded soldiers. Mr. Perls tackled this difficult task with great energy, but the results were at first not very encouraging. He soon found that the usual practice of keeping the blind away from the other workers and employing them on auxiliary work was entirely wrong. The results produced were highly unsatisfactory. From the beginning he worked with the idea of not humiliating the blind by giving them alms, but of paying them for work actually done. It was soon realised, however, that an adequate production on these lines could only be obtained if it was possible to employ the blind on machine work.

This meant groping in the dark. Unknown territory had to be entered and new principles laid down. Special difficulties arose owing to the German Labour Associations, the official undertakers of the insurance of workers against accidents having laid down strict regulations regarding the employment of men in industry. The regulations allowed the employment at machines only of such workmen as were able to realise the danger of accidents and were capable of avoiding them. At first this condition was naturally not fulfilled by the blind, and it was necessary to provide special safety appliances to eliminate danger from moving parts of the machines. At the same time the arrangement of the machines so that faulty work would not be turned out had to be kept in mind. It was consequently necessary to fit the machines with special appliances to adapt them for blind workers. The success of efforts in this direction will be realised when it is stated that up to now more than 150 blind have been trained as machinists at the Siemens-Schuckert Works without a single accident happening. In view of the success attained the Labour Associations waived their regulations and consented to the employment of the blind on machine tools. The ultimate success attained from an economical point of view is illustrated by the fact that by far the larger number of blind workers are able on piece work to earn wages which on the average are higher than those earned by female workers paid at the same rate.

The best idea of the pay of the blind workers will be given when it is stated that at the time the pay of fully-skilled engineers stood at 7 marks per hour in Berlin, the pay of blind workers rose to 5·50 marks per hour with 4·50 marks as an average. The blind receive certain invalid payments from the Government and married workers, by State regulations, also get additional pay on behalf of their wives and children, so that a blind workman is now able to earn by his own efforts an income equivalent to that of any full worker, and to support himself and his family without becoming in any way a drag on public charities. The blind workers receive a minimum wage of 2·10 marks per hour during the period of training. Experience has shown that this period is a comparatively brief one, and the workers are soon in a position to exceed this rate of pay. It is, of course, necessary that they should be treated by the management with every consideration, and that any suitable relaxations of ordinary rules should be allowed as long as they are compatible with the running of the factory. It is desirable in large works that a manager who is capable of taking a special interest in the work should be appointed for the supervision and training of the blind. Considerable intelligence and tact is required for such a post, and the manager must treat his workers with full sympathy and take an interest in their personal affairs. The blind have to be inspired with full confidence, and only by complete mutual understanding can success be attained.

An important point arises in connection with the protection of the blind on their way between the works and their homes. The most desirable arrangement would be to provide a settlement specially for them adjacent to the works. This ideal solution of the problem could not, however, be realised in the case of the Siemens-Schuckert Works owing to local conditions and the present high cost of building. Actually the blind employees are guided to and from their work either by fellow-workers or by relatives, a solution which is not particularly satisfactory, owing to the fact that the blind are dependent upon their guides. Very

FIG. 1. TAPING ELECTRIC MOTOR COILS.

FIG. 2. ASSEMBLING SMALL PARTS.

# THE EMPLOYMENT OF THE BLIND IN WORKSHOPS.

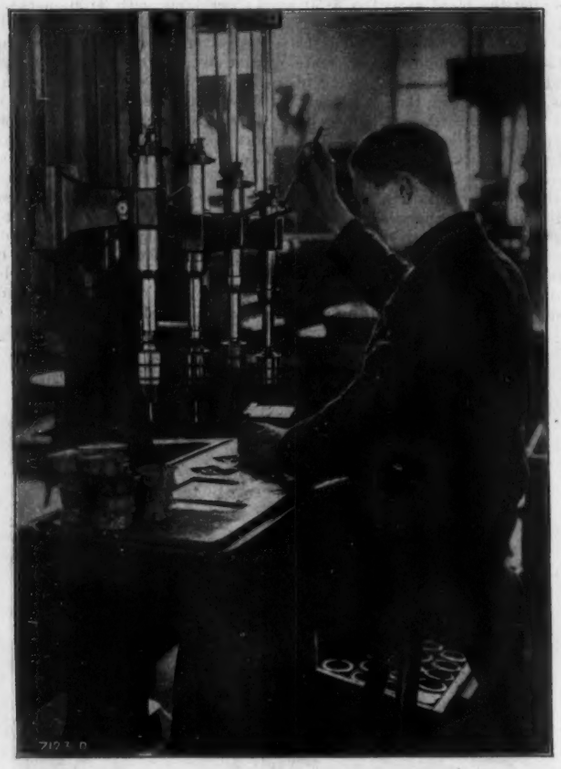


FIG. 3. OPERATION OF A FOUR-SPINDLE DRILL.

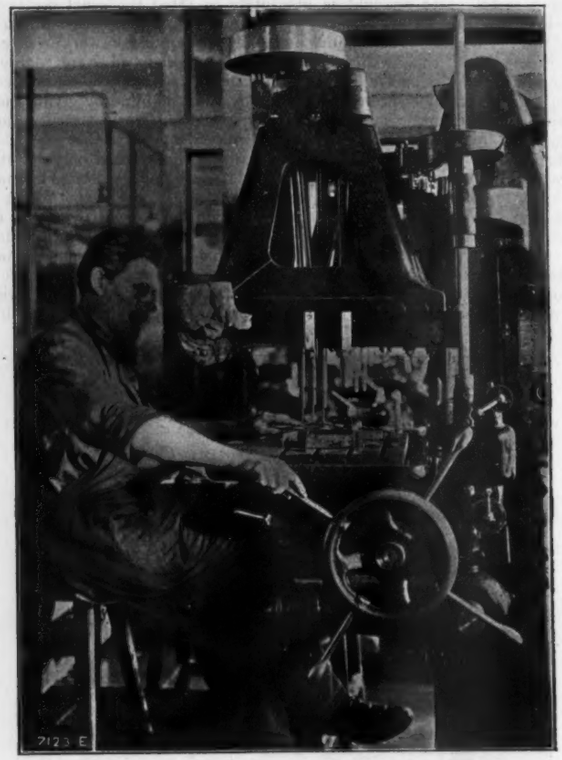


FIG. 4. OPERATION OF MULTI-SPINDLE DRILL WITH TRAVELLING WORK TABLE.

satisfactory results have recently been obtained by the employment of dogs, which are trained for the purpose and are considered most reliable guides. Many of the blind, however, do not feel inclined to trust themselves to dogs, and prefer guidance by fellow-workers or relations.

The type of machining and other work carried out at the Siemens-Schuckert Works covers the manufacture of a very large number of small parts and involves assembling, and the operation of power presses and drilling machines. The range of work undertaken is continually being extended. Some examples of the work done on the machines employed are illustrated in Figs. 1 to 7, on page 715, the present page, and page 717. Fig. 1 shows pure hand work, the wrapping of insulated tape around electric motor coils, and requires no comment. Fig. 2 shows the assembling of metal parts on a base plate. The two metal parts are fitted into a jig over which the drilled base plate is laid. The screws, which carry washers, are put into holes in the base plate and screwed home with a screw-driver. The drilling machine in its various forms has proved very suitable for the employment of the blind, and pillar machines as well as small bench machines have been used. Even the operation of two semi-automatic machines by one blind operator has proved possible.

When a blind operator is employed at a multiple-spindle machine special care must be taken that all moving parts are completely enclosed. In the case shown in Fig. 3, the pieces to be drilled are clamped in a drill jig and the various holes are drilled in a definite order. Nine different holes have to be made in the pieces, and in order to prevent faulty drilling, the drill jig is guided in a table jig mounted on the work-table. The serving of a semi-automatic multiple-spindle drilling machine carrying out two operations is illustrated in Fig. 4. In this case care must be taken to ensure proper guidance of the work by means of table jigs and stops. Injury to the head of the blind operator by coming into contact with the machine framing is provided against by fixing cushions on the dangerous points, as shown in the figure.

FIG. 5. OPERATION OF A SMALL BENCH DRILLING MACHINE.

In the operation shown in Fig. 5 holes are drilled into small metal parts by means of a bench drill. The piece to be drilled is clamped by a chuck which is operated by the left hand while the drill lever is moved down by the right hand. The depth of drilling is determined by a stop.

Machines such as power presses, working with vertically-reciprocating tools, have to be particularly well safeguarded. The guards employed naturally depend upon the particular construction of the machine. The work illustrated in Fig. 6 is the operation of an eccentric driven press with an automatically revolving work table. The press perforates and embosses drawn cylindrical casings which are inserted in recesses of the revolving work-table. The rotation of the work-table and the starting of the reciprocating tool, are controlled

# THE EMPLOYMENT OF THE BLIND IN WORKSHOPS.

FIG. 6. OPERATION OF POWER PRESS WITH REVOLVING WORK TABLE.

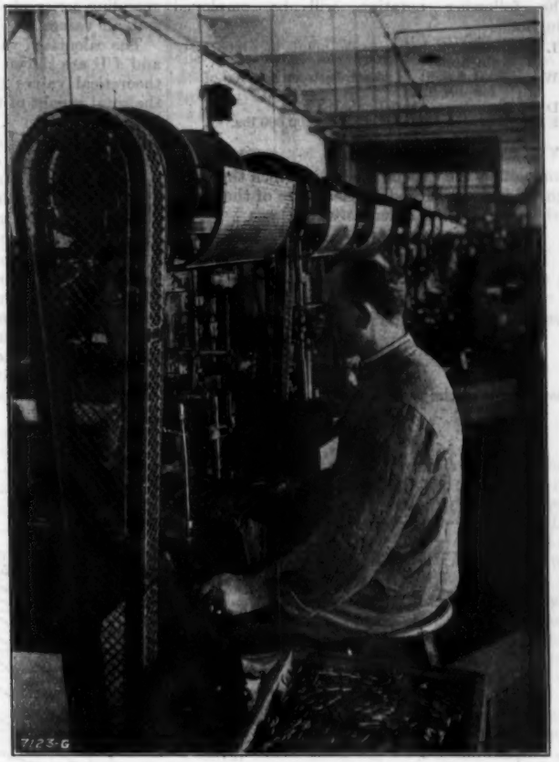


FIG. 7. OPERATION OF POWER PRESS WITH DOUBLE-HAND CONTROL.

by putting the foot on a treadle. As the operator has only to insert the cases, the output is determined by the diameter of the belt pulley, which must be properly chosen. In the die press shown in Fig. 7, the protection of the hands of the operator is effected in a different manner. The machine can only be started if both hands rest simultaneously on safety handles outside the machine. In this manner injuries to the hands are effectively prevented. In milling machines the covering up of the milling cutter is necessary. This may easily be effected by a small hood of sheet metal. In the driving of machines served by the blind, line shafting should be avoided, as the driving belt is likely to be a danger to the operator. An individual electric drive has proved itself eminently successful and should be given the preference over any other.

## SIMPLIFIED APPROXIMATIONS OF CRITICAL SPEEDS.

By G. ARROWSMITH, M.Sc.(Tech.).

IN the design of high-speed turbines, blowers, compressors and electrical machinery, the proportioning of the rotor to avoid the critical speeds is one of the primary considerations, and in many cases this becomes one of the limiting factors in design.

As so many essential features of a machine are affected by the dimensions of the rotor or shaft, it is necessary, in considering any new design, to obtain an approximate estimate of the necessary shaft dimensions during the preliminary stages of the work, and thence to follow very closely the effect upon the critical speed of the numerous modifications which invariably occur before the final design is attained.

The object of this article is to indicate simple approximate methods which may be applied to most cases which occur in practice. It will be shown that in general the critical speed can be estimated to a considerable degree of accuracy by simple calculations which do not involve the tedious construction of bending moment and deflection diagrams.

Experience has shown that for satisfactory running it is advisable to adopt a rotor of such proportions that the critical speed is removed by from 25 per cent. to 35 per cent. from the running speed. Since between these comparatively wide limits satisfactory running may be expected it is at once obvious that extreme accuracy of calculation is not necessary, and for this reason it is usual practice to accept the static deflection curve of the shaft as the basis of calculation. The critical speed is then given by the relation:

$$R_k = 187 \sqrt{\frac{\Sigma w y}{\Sigma w y^2}} \quad . \quad . \quad . \quad (i)$$

$R_k$ = Critical speed in R.P.M.

$y_1, y_2, y_3$, &c. = Deflection in inches at the points of application of the load (lbs) $w_1, w_2, w_3$, &c.*

A large proportion of the examples which occur in practice concern the simplest case of a shaft freely supported at the ends. The error involved in accepting for this the static deflection as compared with the deflection due to the centrifugal loading is no greater than the error which may occur due to variations in the elastic modulus E of the shaft material. Baumann has pointed out that in most cases the approximate critical speed is obtainable from the maximum static shaft deflection Y by the simple relation:

$$R_k = \frac{C}{\sqrt{Y}}$$

The theoretical value of the constant C is easily obtained from equation (i).

For the case of a single concentrated load at the centre of a shaft of negligible weight we have:

$$R_k = 187 \sqrt{\frac{W\ Y}{W\ Y^2}} = \frac{187}{\sqrt{Y}}$$

For a uniformly-loaded shaft of $w$ lb. per inch span and W lb. total weight we have:

$$R_k = 187 \sqrt{\frac{\int wy\ dx}{\int wy^2\ dx}} = \frac{210}{\sqrt{Y}}$$

Baumann's constant can thus vary from 187 to 210. In the usual cases met with in practice the main loading is spread over a certain length near the centre of the span, and the constant is approximately the mean value of the above figures. General experience shows that for a flexible shaft values of C = 195 to 200 give the most accurate results.

For cases where the centre of gravity of the loading is considerably removed from the centre of the span (*i.e.*, from the point of maximum deflection Y) a correction factor can be employed. This will be considered at a later point. The above simplification resulting from the use of the constant still necessitates the construction of the deflection curve of the shaft. We shall now consider how this can in many cases be obviated.

Generally speaking, rotors may be divided into two broad classes:—

(A) Where the shaft is comparatively flexible throughout its span.

(B) Where the centre portion of shaft is of such dimensions as to render it practically inflexible as compared with the end portions of the shaft.

Examples of (A) occur in rotors for blowers, compressors and impulse turbines of the disc type, and of (B) in rotors of the reaction or drum type of turbine. In electrical machinery the line of demarcation is less clear, since in many cases,

* Morley. ENGINEERING, July 30 (page 135) and August 13 (page 205) 1909; also November 22 and 29, 1918 (pages 573, 601).

although the centre portion of rotor is very much stiffer than the end portion, its deflection is by no means negligible.

Considering first the flexible shaft class (A).

The following notation will be employed throughout :—

L = Length of shaft between points of support (inches).
W = Total weight of shaft between points of support (lbs.)
D = Diameter of shaft (inches).
E = Elastic modulus of shaft (30,000,000 lbs./sq. inch.)
Y = Static deflection (inches).

Assuming first the case of a shaft in which the total weight W is concentrated at the centre of the span, the shaft itself being taken as weightless :

$$Y = \frac{W\,L^3}{48\,E\,I} = \frac{W\,L^3}{70{\cdot}7 \times 10^6\,D^4}$$

Inserting the value in Baumann's formula :

$$R_k = \frac{187}{\sqrt{Y}} = \frac{1{\cdot}57 \times 10^6\,D^2}{\sqrt{W\,L^3}}$$

Assuming now the case of the opposite extreme in which the weight W is uniformly distributed over the whole of the span :

$$Y = \frac{5\,W\,L^3}{384\,E\,I} = \frac{W\,L^3}{113 \times 10^6\,D^4}$$

$$R_k = \frac{210}{\sqrt{Y}} = \frac{2{\cdot}23 \times 10^6\,D^2}{\sqrt{W\,L^3}}$$

The general expression for critical speeds can thus be written in terms of weight, diameter and length of span of shaft :

$$R_k = \frac{K \times 10^6\,D^2}{\sqrt{W\,L^3}} \quad . \quad . \quad . \quad \text{(ii)}$$

As shown, value of K varies from 1·57 for a centrally-loaded shaft to 2·23 for uniform distribution of load.

For the general case shown in Fig. 1 the value of K can be obtained for any given ratio of $l/L = \rho$, where

$$Y = \frac{W\,L^3}{41\,E\,I} \times \left[1 - \frac{1}{2}\rho^2 + \frac{1}{8}\rho^3\right]$$

and

$$C = 187\sqrt{\frac{Y\int wy\,dx}{\int wy^2\,dx}}$$

The evaluation of this latter quantity for various values of $\rho$ involves a simple though somewhat tedious calculation. Having obtained this, the values of K for all values of $\rho$ are at once obtainable.

In cases where the shaft diameter is sensibly constant throughout, by selecting the correct value of K a very close estimate of the critical speed can be made by equation (ii). In many cases, however, it is impossible to base an estimate on a parallel shaft since the diameters may vary considerably throughout the span. If, however, a stepped shaft as shown in Fig. 2 be considered a very much wider range can be covered.

Equation (ii) can still be applied to this more general case in the same manner as for the parallel shaft. The centre portion of the shaft of length $l$ and diameter D, carries the load, the remaining unloaded portion of the shaft having a reduced diameter $d$. For any definite ratio of $d/D$ a corresponding series of values of K can be obtained to suit all values of $l/L = \rho$.

The calculated values of K for various values of $\rho$ and $d/D$ are shown in Table I. In obtaining these theoretical values the assumption was made that the total weight of the shaft was concentrated over the centre span $l$. In actual practice the end portions of the shaft of diameter $d$ represent a certain percentage of the total shaft weight, this percentage being larger the higher the ratio $d/D$. The effect of assuming the whole of the weight to be situated on the centre span of the shaft is to obtain a somewhat low value for the critical speed.

To compensate for this assumption, an increased value of K can be employed, and thus the curves in Fig. 3 have been constructed. The method adopted to obtain these final curves was to analyse the results of a large number of detailed critical speed calculations and so to obtain mean corrections on the theoretical values given in Table I, on page 719.

It will be seen that Fig. 3 shows values of K for ratio $d/D$ varying from unity to 0·6. Where the ratio is less than this the rigidity of the centre portion of shaft becomes relatively great as compared with the end portions, and the second method of treatment described later should be employed. As a matter of interest, the approximate values of Baumann's co-efficient C are shown. This curve is only an approximation since values of C depend to a slight extent upon the ratio $d/D$.

In most cases met with in practice the loading of the shaft is approximately central between the points of support. If the load is to an appreciable extent removed from the centre of the span, the effect is slightly to increase the critical speed. A correction factor can be obtained with sufficient accuracy from the deflection of a beam with an out-of-centre load :

$$Y = \frac{W\,L^3}{48\,E\,I} \times \left[1 - 4\epsilon^2\right]^2$$

where $\epsilon = \frac{e}{L}$ the eccentricity of loading (see Fig. 2).

Thus the correction factor $f = \frac{1}{1 - 4\epsilon^2}$.

These values are given in Fig. 4.

By considering a definite example the simplicity of the above method can be illustrated and further an idea of the degree of accuracy to be expected can be obtained.

Fig. 5, page 719, shows a turbine shaft for a small machine of 3,000 r.p.m. The loading of the shaft, due to its own weight and that of the various wheels is indicated. The following points should be noted : The centre portion of the shaft is stepped to take the wheels, the loading of this centre portion is by no means evenly distributed ; the reduced diameter, 6¾ in., corresponding to the glands of the turbine, has a considerably greater length at the steam end than at the exhaust end of the rotor, and this has the effect of throwing the loaded portion of shaft away from the centre of the span.

In applying the approximate formula we reduce the shaft to the form shown in Fig. 2.

The main diameter of shaft is equal to that of the middle step D = 8·0625.

The reduction in diameter at the bearings is ignored and the reduced diameter is taken throughout as $d = 6{\cdot}75$ in.

The total weight between centres of bearings is 3,180 lb.

We thus have :

| | |
|---|---|
| D = 8·0625 in. | L = 62 in. |
| $d$ = 6·75 in | $l$ = 25 in. |
| $d/D$ = 0·838 | $\rho = l/L$ = 0·403 |

Corresponding value of K from Fig. 3 = 1·585.

$$R_k = \frac{1{\cdot}585 \times 10^6 \times 8{\cdot}0625^2}{3{,}180 \times 62^2} = 3{,}740.$$

Owing to the unequal gland lengths the shaft is eccentrically loaded by about 3 in. Referring to Figs. 2 and 4 we have $\epsilon = \frac{3}{62} = 0{\cdot}048$, and correction factor $f = 1{\cdot}01$.

The corrected critical speed thus becomes :

3,740 × 1·01 = 3,780 R.P.M.

Below the shaft in Fig. 5 the bending moment and static deflection curves are shown. These were obtained by the usual graphical method. It will be seen that the maximum shaft deflection is 0·0027 in.

From Fig. 3, where $\rho = 0{\cdot}403$, Baumann's constant is 199. Thus :

$$R_k = \frac{199}{\sqrt{0{\cdot}0027}} = 3{,}830 \text{ R.P.M.}$$

Applying the fuller summation method, equation (i), we obtain the following results :—

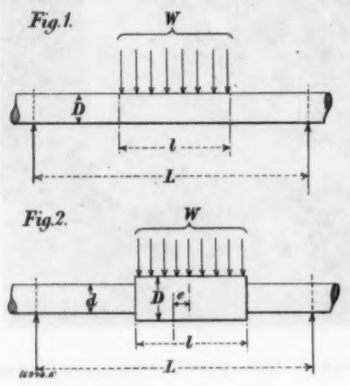
| w. | $y \times 10^3$ | $wy \times 10^3$ | $wy^2 \times 10^6$ |
|---|---|---|---|
| 25·0 | 0·3 | 7·5 | 2·0 |
| 145·0 | 1·16 | 168·0 | 195·0 |
| 145·0 | 2·1 | 305·0 | 640·0 |
| 640·0 | 2·55 | 1,630·0 | 4,160·0 |
| 30·0 | 2·67 | 80·0 | 214·0 |
| 380·0 | 2·7 | 1,025·0 | 2,770·0 |
| 390·0 | 2·62 | 1,020·0 | 2,670·0 |
| 400·0 | 2·5 | 1,000·0 | 2,500·0 |
| 400·0 | 2·3 | 920·0 | 2,115·0 |
| 410·0 | 2·05 | 840·0 | 1,720·0 |
| 95·0 | 1·6 | 152·0 | 243·0 |
| 95·0 | 1·0 | 95·0 | 95·0 |
| 25·0 | 0·3 | 7·5 | 2·0 |
| 3,180·0 | | 7,250·0 | 17,326·0 |

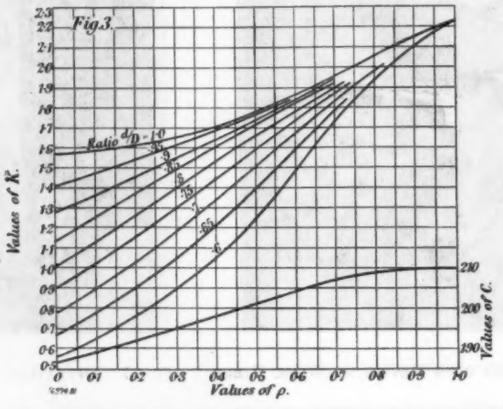
$$\Sigma\,wy = 7{\cdot}25$$

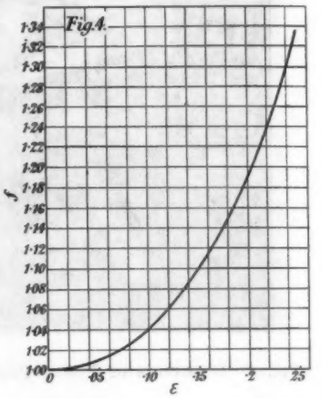
$$\Sigma\,wy^2 = 0{\cdot}017326.$$

$$R_k = 187\sqrt{\frac{7{\cdot}25}{0{\cdot}017326}} = 3{,}830.$$

From the results of these calculations we see that by employing the correct value of Baumann's constant a figure exactly corresponding to the fuller calculated value was obtained. Further, the figure obtained by the simple approximation after correcting for eccentricity of loading differs from the accurately-calculated value by about 1¼ per cent., and as already pointed out an error of this magnitude is of no practical consequence in view of the fact that the elastic modulus upon which



calculations are based is to a certain extent indeterminate.

A considerable proportion of the cases which occur in practice can by a certain amount of judgment be reduced to the form of a double stepped shaft.

Should the end shaft vary considerably in diameter an equivalent value of $d$ can be calculated by making a summation for the various steps. In Fig. 6 a stepped end shaft is shown.

Summing the values $\frac{x^2\,dx}{d^4}$ for all steps, we get a quantity $\Sigma$, then from this the equivalent diameter of end shaft:

$$d_e = \left(\frac{B^3}{3\,\Sigma}\right)^{\frac{1}{3}} \text{ (when } \beta = \text{length of end shaft)}$$

After a little experience it is usually possible to estimate the equivalent diameter by inspection.

Fig. 5.

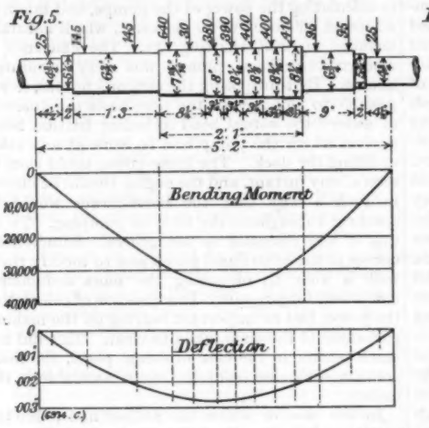



Fig. 6.

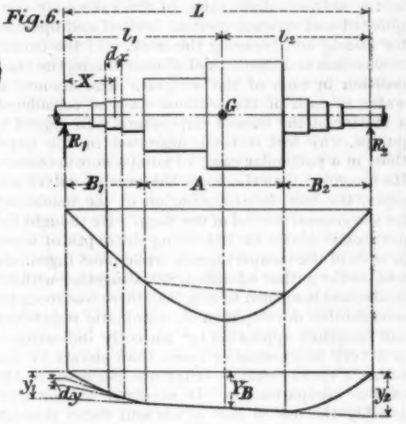



Fig. 7.

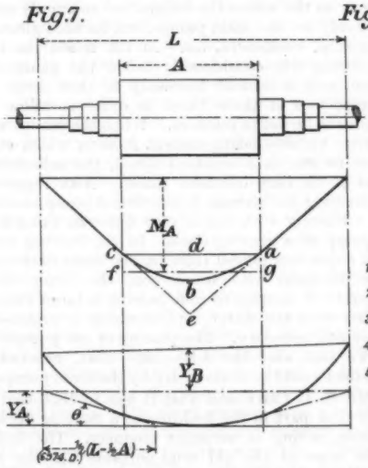
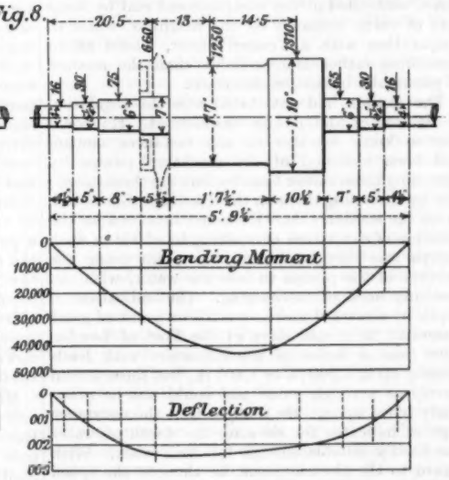



Fig. 8.




In the case of electrical rotors the centre portion of the shaft is frequently not of circular section, but by employing an equivalent value of D to give the correct moment of inertia of section, equation (ii) can still be employed.

TABLE I.—*Theoretical Values of K.*

| Ratio $d/D$ = | 1·0 | 0·9 | 0·8 | 0·7 | 0·6 |
|---|---|---|---|---|---|
| $\rho = l/L$ | | | | | |
| 0·0 | 1·57 | 1·27 | 1·005 | 0·77 | 0·565 |
| 0·1 | 1·58 | 1·355 | 1·1 | 0·866 | 0·65 |
| 0·2 | 1·605 | 1·425 | 1·203 | 0·975 | 0·75 |
| 0·3 | 1·64 | 1·505 | 1·32 | 1·11 | 0·88 |
| 0·4 | 1·683 | 1·585 | 1·455 | 1·26 | 1·03 |
| 0·5 | 1·755 | 1·69 | 1·585 | 1·44 | 1·23 |
| 0·6 | 1·84 | 1·8 | 1·735 | 1·63 | 1·46 |
| 0·7 | 1·945 | 1·925 | 1·89 | 1·83 | 1·725 |
| 0·8 | 2·09 | 2·08 | 2·06 | 2·04 | 1·99 |
| 0·9 | 2·2 | 2·2 | 2·19 | 2·17 | 2·15 |
| 1·0 | 2·23 | 2·23 | 2·23 | 2·23 | 2·23 |

Considering now the type of rotor class (B), as shown diagrammatically in Fig. 6.

The centre portion A, which constitutes the main loading, is extremely rigid compared with the end shafts $B_1$ and $B_2$, consequently the whole of the shaft deflection may be taken as due to the flexure of the end shafts.

Examining the bending moment diagram we see that this consists approximately of a straight line diagram for the portions $B_1$ and $B_2$, the parabolical centre portion of the diagram being of no consequence due to the extreme rigidity of this portion of the rotor.

The critical speed may be obtained by determining the deflection at the centre of gravity of the complete rotor, and using this with the constant C = 187 for concentrated loading.

The centre of gravity of rotor is indicated at G, at distances $l_1$ and $l_2$ from the points of support.

In applying the concentrated loading formula we must take an effective rotor weight obtained by adding half the weight of the shaft ends to the main or concentrated load of the centre portion thus:

$$\text{Effective rotor weight W} = \begin{cases}\text{Weight of section A +} \\ \frac{1}{2}\text{ Weight of sections } B_1 \text{ and } B_2.\end{cases}$$

$$\text{Reaction } R_1 = W \times \frac{l_2}{L}$$

$$R_2 = W \times \frac{l_1}{L} \quad . \quad . \quad . \quad . \quad . \quad \text{(iii)}$$

$$\text{Deflection at G due to flexure of portions } B_1 \text{ and } B_2 \Big\} Y_B = \frac{y_1\,l_2 + y_2\,l_1}{L} \quad . \quad . \quad \text{(iv)}$$

Considering the flexure of the end shafts, by dividing each end into about four sections we can obtain the amount of deflection $d\,y$ due to each of these sections:

X = Distance from point of support.
$d$X = Length of section of shaft.
M = Bending moment at this point.
= R X

$$d\,y = \frac{M}{E\,I} \cdot X \cdot d\,X$$

$$= \frac{64\,R}{\pi\,E} \cdot \frac{X^2\,d\,X}{D^4}$$

Where D = the diameter of the section under consideration.

The total deflection of the end shaft is thus obtained by the summation of this quantity for the four or more sections:

$$y_1 = \frac{64\,R}{11\pi\,E} \cdot \Sigma\,\frac{X^2\,d\,X}{D^4}$$

The summation to obtain the quantity $\Sigma\,\frac{X^2\,dX}{D^4}$ for the two shaft ends is easily carried out without the necessity of any geometrical construction and denoting the values of this by $\Sigma_1$ and $\Sigma_2$, we obtain from (iii) and (iv):

$$Y_B = \frac{64\,W}{\pi\,L^3\,E}\left[l_2^3\,\Sigma_1 + l_1^3\,\Sigma_2\right]$$

$$= \frac{6{\cdot}8\,W}{10^7\,L^3}\left[l_2^3\,\Sigma_1 + l_1^3\,\Sigma_2\right] \quad . \quad . \quad \text{(v)}$$

and

$$R_k = \frac{2{\cdot}27 \times 10^5\,L}{\sqrt{W\,(l_2^3\,\Sigma_1 + l_1^3\,\Sigma_2)}} \quad . \quad . \quad . \quad \text{(vi)}$$

In many cases the centre of gravity of the rotor is very nearly at the centre of the span, we then have $l_1 = l_2 = \frac{1}{2}$ L, and equations (v) and (vi) simplify to:

$$Y_B = \frac{1{\cdot}7\,W}{10^7}(\Sigma_1 + \Sigma_2) \quad . \quad . \quad \text{(vii)}$$

and

$$R_k = \frac{4{\cdot}54 \times 10^5}{\sqrt{W\,(\Sigma_1 + \Sigma_2)}} \quad . \quad . \quad . \quad \text{(viii)}$$

In the above treatment of the rigid rotor we have disregarded any flexure which may occur in the centre portion A. If the length of this portion is not more than about half the total span L, and its diameter is not less than three times the maximum shaft diameter, the error due to this will be for practical purposes negligible. In cases where the flexure of the centre portion cannot be neglected an approximation of the additional deflection due to this can be made by taking an average uniform bending moment and an average moment of inertia.

Referring to Fig. 7, the average height of the parabola $a\,b\,c$ is one-third of the height $d\,e$ of the triangle $a\;e\;c$. The average bending moment represented by the dotted line $f\,g$ may be substituted for the true bending curve $a\,b\,c$, and since $c\,f$ = one-third $d\,e$, we have for the average uniform bending moment of centre portion:

$$M_A = \frac{W}{4}\left(L - \frac{2}{3}A\right)$$

Assuming this uniform value of M, the curvature of the centre portion A is uniform and equal to $\frac{d^2\,y}{dx^2} = \frac{M_A}{E\,I}$. Whence, referring again to Fig. 7:

$$\theta = \frac{d\,y}{d\,x_{\left(x=\frac{A}{2}\right)}} = \frac{M_A}{E\,I} \times \frac{A}{2}$$

The extra deflection $Y_A$ due to the flexure of the centre portion A is thus:

$$Y_A = \theta \times \tfrac{1}{2}(L - \tfrac{1}{2}A)$$

$$= \frac{W\,A}{16\,E\,I}(L - \tfrac{2}{3}A)(L - \tfrac{1}{2}A)$$

$$= \frac{W\,L^3}{16\,E\,I}\,(r - 1{\cdot}166\,r^2 + 0{\cdot}333\,r^3) \quad \text{where } r = A/L.$$

$$= \frac{a\,W\,L^3}{16\,E\,I} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{(ix)}$$

The values of $a$ being as follows:—

| $r$ = | 0·3 | 0·35 | 0·4 | 0·45 | 0·5 | 0·55 | 0·6 |
|---|---|---|---|---|---|---|---|
| $a$ = | 0·204 | 0·221 | 0·235 | 0·244 | 0·251 | 0·258 | 0·264 |

Adding this deflection to that obtained from (v) and (vii) we obtain the corrected value for critical speed:

$$R_k = \frac{187}{\sqrt{Y_A + Y_B}} \quad . \quad . \quad . \quad . \quad \text{(x)}$$

As an example of this second type, Fig. 8 shows a rotor suitable for a turbine of the disc and drum type. The rotor consists of a solid forging with a disc and balance piston mounted separately on the end shaft.

Effective weight W = (3,220) + ($\frac{1}{2}$ × 232) = 3,336 lbs.
L = 69·5 in.

In finding the position of the centre of gravity only the main loads need be considered.

$$l_1 = \frac{(660 \times 20{\cdot}5) + (1{,}250 \times 33{\cdot}5) + (1{,}310 \times 48)}{660 + 1{,}250 + 1310} = 36{\cdot}7 \text{ in.}$$

$l_2$ = 32·8 in.

| $d X_1$ | $X_1$ | D. | $\frac{X^2 d x}{D^4}$ | $d X_2$ | $X_2$ | D. | $\frac{X^2 d x}{D^4}$ |
|---|---|---|---|---|---|---|---|
| 4·5 | 2·25 | 4·00 | 0·089 | | | | |
| 5·0 | 7·0 | 5·25 | 0·345 | 4·5 | 2·25 | 4·00 | 0·089 |
| 4·0 | 11·5 | 6·00 | 0·408 | 5·0 | 7·0 | 5·25 | 0·345 |
| 4·0 | 15·5 | 6·00 | 0·693 | 3·5 | 11·25 | 6·0 | 0·397 |
| 5·5 | 20·25 | 7·00 | 0·940 | 3·5 | 14·75 | 6·0 | 0·587 |
| | | $\Sigma_1$ = | 2·475 | | | $\Sigma_2$ = | 1·418 |

Inserting these values in equation (vi) we obtain:

$$R_k = \frac{2{\cdot}26 \times 10^5 \times 69{\cdot}5}{\sqrt{3{,}336\,[(32{\cdot}8^2 \times 2{\cdot}475) + (36{\cdot}7^2 \times 1{\cdot}418)]}} = 4030.$$

This figure is based on the assumption that there is no bending in the heavy drum portion of the rotor. It is obvious from the proportion of the rotor that this can only be very slight.

Applying equation (ix) we have:

$$\frac{A}{L} = \frac{30}{69{\cdot}5} = 0{\cdot}432$$

$$a = 0{\cdot}248$$

Average value of I = 8,250.

$$Y_A = \frac{0{\cdot}248 \times 69{\cdot}5^3 \times 3{,}336}{16 \times 30 \times 10^6 \times 8{,}250} = 0{\cdot}00007 \text{ in.}$$

From equation (v):

$$Y_B = 0{\cdot}00215 \text{ in.}$$

Thus corrected value:

$$R_k = \frac{187}{\sqrt{0{\cdot}00215 + 0{\cdot}00007}} = 3{,}960$$

The graphically-constructed bending moment and deflection diagrams are shown in Fig. 8, page 719. Applying the ordinary summation method equation (i), we obtain:

| w. | $y \times 10^5$ | $w y \times 10^5$ | $w y^2 \times 10^5$ |
|---|---|---|---|
| 16 | 0·35 | 5 | 2 |
| 30 | 1·17 | 35 | 41 |
| 75 | 2·0 | 150 | 300 |
| 660 | 2·36 | 1,557 | 3,680 |
| 1,250 | 2·3 | 2,870 | 6,610 |
| 1,310 | 2·04 | 2,670 | 5,460 |
| 65 | 1·74 | 113 | 197 |
| 30 | 1·25 | 37 | 47 |
| 16 | 0·44 | 7 | 3 |
| | | 7,444 | 16,340 |

$$R_k = 187 \sqrt{\frac{\Sigma w y}{\Sigma w y^2}} = 187 \sqrt{\frac{7{\cdot}444}{0{\cdot}01634}} = 3{,}990$$

These figures show that the simple approximate method gives results in very close agreement with accurately-calculated value.

Summarising the general conclusions arrived at are:—

Critical speeds can in very many cases be obtained without resource to tedious graphical constructions of bending moment and deflection diagrams.

For shafts (class A) comparatively flexible throughout their span, equation (ii) can usually be employed where ratio $d/D$ is not less than 0·6.

For values of $d/D$ of less than 0·6 the shaft becomes more or less class B when equations (v) or (vii), (ix) and (x) can be used.

In many cases where $d/D$ is considerably less than 0·6 the flexure of the centre portion of shaft is negligible and equations (vi) or (viii) may be employed.

## THE INSTITUTION OF MECHANICAL ENGINEERS.

An ordinary general meeting of the Institution of Mechanical Engineers was held on Friday last, the 18th inst., at Storey's Gate, Westminster, the chair being taken by the president, Captain H. Riall Sankey, C.B., O.B.E., R.E.(Ret.).

The President first made reference to the death of Mr. E. Windsor Richards, a past-president of the Institution, who became a member is 1866, a member of council in 1882, and occupied the president's chair during the years 1896–97. The President also alluded to the death of Sir C. Douglas Fox, who had been a member since 1866. Sir Douglas was, at the time of his death, senior past-president of the Institution of Civil Engineers, and only two meetings ago he had spoken on the occasion of the inauguration of the new president.*

### Machinery of Floating Docks.

After the formal business of the meeting, Mr. E. H. Salmon, D.Sc., summarised his paper on "The Machinery of Floating Docks," and exhibited on the screen a series of photographic and other views illustrative of certain points dealt with in the paper. Dr. Salmon, when giving his *resumé*, revised some of the figures for costs given in his paper. As costs are still fluctuating there is little object in giving these, the basis of comparison remaining as given in the paper. We commence the reprinting of this paper in another part of this issue (*vide* page 739), and accordingly proceed to the discussion.

Mr. H. J. Deane, of the Port of London Authority was the first speaker. He had been most interested in the author's description of the extremely complicated and delicate method devised and operated for raising and lowering the dock, and the control mechanism and the method of ascertaining the exact position in each of the sections. The amount of water in each of the sections was, he considered, a matter of the utmost imporatnce. In regard to pumps, why had it been suggested in the paper that, in a particular case, 10 pumps were necessary. He imagined that the fewer the pumps, valves and pipes, the less the complication of the machinery for the general control of the dock. He thought the pneumatic device for indicating the depth of water in each of the compartments, while most ingenious, was, as the author admitted, not altogether without faults, and it seemed to him that there was room for considerable development in automatic registering and recording apparatus for correctly indicating—in a very much smaller space than shown by the author's views—exactly what was going on in the various compartments. It occurred to him that possibly the use of flow of air and water through pipes, controlled at the compartment end by some sort of valve operated by the height of water in conjunction with a Venturi meter, would afford something rather more reliable than the method of pneumatic indication described.

The author had not stated how the regulation of the valves and pumps was secured. He would like to know whether in any instances control had been obtained of the discharge pumps by throttling them rather than by slowing them down; also by throttling them on the discharge side as well as on the suction side. He asked this because the question of cavitation or sucking in of air in such pumps was very important, the point being the liability of the pumps to lose the water, with the resulting need of re-charging. The indication of depth by electrical means was also a point of great interest. At a cold store of the Port of London there was a series of thermometers with leads ranging up to 1,300 ft. or 1,400 ft., but these served merely as a rough guide and could not be absolutely relied upon. He thought that the resistance type of indicator for showing the depth of water was hardly reliable enough for dock work. With regard to the electric crane, he thought the speed of lift given, 15 ft. to 25 ft. per minute, was very slow. Turning to electric capstans, he did not know of any capstan directly driven by electricity which could be regarded as a sound job; the majority of them embodied a slipping apparatus, which no mechanical engineer could consider ideal. He wished to ask why hydraulic capstans and hydraulic control of the valves was not resorted to; these he thought might be arranged without accumulators and reciprocating engines.

The London Hydraulic Power Company had long since installed high-pressure multi-stage pumps which were doing excellent work. The Clyde Navigation Trustees had decided to instal three similar pumps, two electrically-driven and the third by a steam turbine. In the case of the electrically-driven pumps no accumulator was to be used. Let them consider a point on the "head" line of Fig. 19 of the paper, say, where the "efficiency" line crossed it, at an output of just over 8,000 gallons per minute—and the accumulator loaded at that particular head; when the demand decreased the head went up, and the accumulator at once rose to the top and remained there. When the demand increased the accumulator went down to the bottom, because the head dropped. In the result, the accumulator was absolutely of no use. He thought the pumps he had referred to gave an excellent method of providing power for the operation of sluices, and possibly the starting and stopping of the engines. He thought that the possibilities of adapting oil transmission to the operation of valves where a good deal of nicety of adjustment was wanted, were very considerable.

Mr. G. P. Mair observed that the author made no reference to the time taken in lifting the dock; this had a considerable bearing on the power required of the engine. Of course the time element was influenced by a good many things. The author, in calculating the power of the pumps, had taken an all-round efficiency of 40 per cent., which naturally included engines, shafting, &c. The efficiency of modern centrifugal pumps was very accurately known. By transposing the author's figures, it was possible to plot against the time basis the quantity of water—the actual head including friction head, against which the pump had to work at any stage of lifting the dock. The horse-power could then be seen at any instant, and the engine should be chosen in such a way that the horse-power would be constant throughout the time of pumping. To do this it was essential to use general characteristic curves of the centrifugal pump and to modify them with a view to obtaining the most economical machinery for pumping. This question of calculating the power had an important bearing on the maker's guarantee of the time taken to clear. This did not much matter in the case of steam plant, the main point in such case being the steam available in the boilers.

In the case of which the author had exhibited views on the screen the boilers had to supply steam not only for the main pumps, but for the lighting of the ship, workshops, &c. At the trials, the time of lifting was considerably below the guaranteed time, and it became necessary to shut down the pumps two or three times in order to allow the shores to be put in position. When the pumps were driven by alternating-current motors, which could only be run at a constant speed, the calculations had to be very carefully made. With regard to recharging the pumps, a centrifugal pump as fitted to a floating dock was a very different thing from a pump at a graving dock. In the floating docks the pump was placed right on the main drain, and the discharge was submerged, the pump being capable of sucking in and passing a large amount of air with the water, and charging arrangements were not necessary. The placing of the pumps low down had also the advantage that, practically, the dock could be drained dry by the main pumps.

Mr. E. L. Clark said that it was in 1876 that he first took part in the building of a floating dock in Russia, acting as assistant engineer. The boilers used were of the old semi-portable Clayton and Shuttleworth type used for thrashing. They experienced considerable trouble with slipping and the breaking of the horn-beam cogs. The centrifugal pump of that period had about six cast-iron arms, which spun round. These arms broke, and as they broke the efficiency of the pump increased remarkably until only three were left, after which efficiency declined. There was no arrangement to show the depth of water in the pontoon, and nothing special for opening the valves, which were ordinary plug valves pulled open with a lever. It was well for the more highly-developed engineer of modern times to reflect that despite the absence of modern facilities great things were accomplished in those early days.

Mr. Richard W. Allen, C.B.E., said the author had stated that the efficiency of the pumps and motors or engines on the test bed was very different from the efficiency of the same plant averaged over a lift. These words, he thought, were liable to misconception. He could see no reason why a well-designed and well-constructed pumping plant should not give exactly the same efficiencies during its actual performance of pumping out the dock as on the test bed; it should do so. On referring,

* Memoirs were published in our last issue of the late Mr. E. Windsor Richards and the late Sir Douglas Fox, see pp. 701 and 703 *ante*.—Ed. E.

however, to Fig. 1 in the paper—the plan of the pipes of a floating dock—and on reading the author's remarks on certain devices he had proposed to prevent whirls, he had come to the conclusion that if Dr. Salmon would give greater attention to the arrangement of the pipes he would obtain more satisfactory results. The plan showed that the suction pipes were joined to one main pipe, or trough, at right angles. There should, he thought, be much larger areas at the points of junction in the suction pipe, and, to prevent whirlpools, more room should be allowed underneath the suctions of all the pumps, when better efficiency would be obtained.

Again, the bellmouths shown in the paper were of extremely crude form; and with more attention given to the suction entrances better efficiency would be secured. With regard to the author's statement that the pumps were, as a rule, of the vertical spindle type, he wished the author had been more explicit, and used the words "must be of the vertical spindle type." The phrase "as a rule" implied exceptions and therefore the use of other types. He recalled an experience which he had shared with the President, in which some thirty years ago they had received a telegram worded: "Come quickly, dock upside down." They were not responsible for that. In the report on the incident it was submitted that the accident was due to arranging the pumps too high, together with the unsatisfactory design of piping. The engineers were told what to do, and he believed the dock had since worked satisfactorily. Horizontal spindles and long suctions invited trouble. With regard to the recommendations made by Mr. Deane, he, Mr. Allen, would multiply the pumps and have no pipes at all.

Mr. Asa Binns said it was true that the floating dock had done splendid service, but he believed he was right in saying that, throughout the British Empire, floating docks were outnumbered by dry docks, in the proportion of something like 10 to 1. Hitherto floating docks had found place in the Baltic, on the American seaboard and in inland seas, where there was little variation of tide level. The floating dock had the great advantage of mobility; if not successful at one site it could be transferred to another. There were narrow sites along river estuaries where a dry dock could not be installed. There were cases in which solid strata for foundations could only be found at great depth. In these cases the floating dock would have great advantage. On the other hand, he thought the dry dock was superior in the matter of safety. The King George V Dock was 750 ft. long, 100 ft. wide and 35 ft. deep, and capable of taking a 30,000-ton liner. It would be difficult to find a location for a floating dock of like dimensions within six miles of St. Paul's; indeed, within 50 miles. In the King George V Dock, the suction culvert was quite short, leading to a large sump and a short suction pipe from the centrifugal pump. The short suction pipe was of bell-mouthed section; the submerged delivery was straight through the wall into the wet dock. There were twin pumps of 820 h.p., electrically driven, direct coupled to motors using current at 6,000 volts, Working together, the pumps could de-water the dry dock (3,500,000 cub. ft. of water) in 3 hours. The simplicity of the arrangement, as compared with multiplicity of pumps and complexity of piping, such as had been shown on the screen, greatly appealed to him.

It was possible, in the dry dock above mentioned, to have a travelling crane of 25 tons capacity and 80 ft. reaching out to the middle of the dock. Such an appliance, weighing well over 200 tons, could not be used on a floating dock. With regard to the leading-in gear, illustrated in Fig. 36 of the paper, he would like to know whether it had been much adopted; for a large dock the arrangement seemed rather feeble. The mechanical side shores and bilge shores were interesting, but were of greater advantage in a floating dock, the conditions of docking being, particularly in a choppy sea, less comfortable in a floating dock than in a dry dock.

Mr. E. R. Dolby said, if he correctly understood the author, the type of registration apparatus for the depth of water in the tanks resembled one which he had used on a small scale, embodying a diminutive diving bell connected by a copper pipe of very small diameter to the dial gauge which acted on the principle of the Bourdon gauge. Could anyone suggest a more suitable method of recording the depths of water in the tanks?

Mr. L. H. Peter, referring to the previous speaker's remarks on depth indicators, said he believed that the method employed in the case of the Panama Canal Docks would be quite suitable for floating docks. The method was purely electrical, and did not depend on compressed air.

Mr. E. White asked what would happen to the ship in a floating dock if another ship, say, going down the river, came into collision with the side of the dock.

Dr. E. H. Salmon, in reply, said the reason for employing so many pumps was that the dock was usually subdivided into sections with a view to self-docking, or lifting a part of itself; hence it was desirable to have a pump in each section. There were advantages in a few pumps and pipes, but that could not always be arranged. Limitations of space in a floating dock also had to be considered. The size of the side wall was usually fixed by considerations of stability, and that limited the size of the pump put in. The chief consideration, however, was the number of sections in the dock. It was common practice also to duplicate pumps. The complication and control of the pipes might seem to be rather a serious matter, but was in practice immaterial; once the ship was secured there was very little valve regulation, it being then merely a question of pumping out. With regard to the use of the Venturi meter principle, he would consider it; the idea was good. The pneumatic water-level indicator was useful in a small scale application, but with a dock 600 ft. or 700 ft. long, with the long leads, small leaks were very difficult to locate in piping arrangements. Electrical systems had been tried and worked quite well. It was necessary to throttle the pumps when lifting the maximum ship, but control was usually achieved on revolutions by slowing down the engines.

In connection with floating docks he had never worked capstans hydraulically, but had worked valves hydraulically. No accumulator was used. He thought the suggestion to employ multiple-stage pumps for working capstans, &c., interesting. To operate the valves a shaft was sometimes carried along the dock, driven continuously by an electric motor. The valve gear could be thrown in and out by means of clutches. Another system, though rather expensive, was to have an electric motor on each valve, this giving ideal control. The time of lift depended so much upon circumstances that he had not given any general rules. In a busy port, a quick lift would be required, but for a port in the middle of the Pacific, say, where perhaps one ship was docked in a fortnight, speed of lift did not matter. The 40 per cent. efficiency figure he had given was obtained from the actual water horse-power needed to lift the dock, which was compared with the ammeter reading for the actual electric power consumed by the dock. In sinking a dock a certain amount of work was taken out of it, and it was a simple calculation to find, from the time of lift, the actual frictional head. In his figure of 40 per cent. that had been taken into account, and he could not agree that the arrangement of pipes criticised was responsible for the 40 per cent.; there was more in the matter than that. Horizontal-spindle pumps had been used with success in many docks. In threading the pipes through the various frames of the dock it was not always easy to do as one liked with them, although on the actual job it might be possible to introduce many improvements.

On the question of the safety of the floating dock, the floating dock was in no danger if properly designed. With a floating dock the 25-ton crane mentioned would be used on a small pontoon, and then would not crowd up the dock. The leading-in gear mentioned had been fitted to a number of battleship docks, the Pola Dock of 23,000 tons, and the Rio Dock of 20,000 tons; this gear merely gave a certain amount of directive effort to the ship. He wished to read a statement by the manager of the Cardiff Dock, with regard to the work accomplished in one tide—practically three hours. On the flood tide reaching the pontoon sufficiently a steamer was floated off. The pontoon was pumped up and refloated; an additional set of high keel blocks was put down, the pontoon was re-sunk and another steamer docked on it, the pontoon being again pumped up. He might quote also the case of a small off-shore dock of 425 tons capacity at Aberdeen. During five complete years' working this dock handled 1,589 vessels of an aggregate gross tonnage of 217,484 tons; that was, 318 vessels per year of 308 working days. On one occasion, five vessels had occupied the dock within a period of 12 hours. In the case of the 25,000-ton commercial dock, for the actual lifting of a ship, 40,000 tons of water would have to be pumped out of the floating dock, while to re-lift the dock required the pumping of 15,000 tons of water, making 55,000 tons of water in all. Assuming a graving dock of identical profile and length, he found that to dock the vessel, 30,000 tons (maximum ship) had to be pumped, while to empty the dock again 56,000 tons of water must be pumped, or 86,000 tons in all. In the case of a smaller ship the amount to be pumped would be more.

With a graving dock, large drainage pumps had to be kept going the whole time, and these were often nearly as large as the entire pumping plant of a floating dock. At Valparaiso, they had been willing to put ships on the floating dock when the waves were 4 ft. high. At Cardiff a ship was being swung round in its moorings when it crashed into the floating dock previously mentioned. Only one man, a fireman, was aboard the dock, but he at once got a mat, and threw it over the hole. He then started the main pumps, and kept them going until assistance arrived. The dock was pumped well above the water and a temporary patch was made. It never sank.

The President commented upon the case of the dock referred to by Mr. Allen, remarking that he had supplied the engines and Mr. Allen the pumps; the engines worked excellently, and so did the pumps, when supplied with water. The pipes had been made by foreign manufacturers, and had very thin flanges, with the result that each joint leaked and let in air. When the joints were put right the pumping arrangements worked well.

He then announced that the annual dinner of the Institution would take place on Thursday, December 15, and that the next ordinary general meeting would be held on Friday, December 16, when papers on "Dock Elevating Machinery," by Gardner Mitchell, and on "The Discharge of Grain Cargo in the Port of London by Pneumatic Elevators," by R. C. Knight, would be read and discussed. Informal meetings of the Institution would be held on Friday, November 25, and on December 2 and 9 next. The further announcement was made that Mr. G. R. Sharpley, Member of Council, had retired, and the Council had appointed Lieut.-Colonel E. Kitson Clark to fill the vacancy. Lieut.-Colonel Kitson Clark would stand for re-election at the forthcoming annual general meeting.

## 300-H.P. TWO-CYCLE DIESEL ENGINE.

The Ansaldo-San Giorgio, of Turin and Spezzia, which has been building two-cycle Diesel engines for many years, for both naval and land work, is introducing a new series of such engines intended primarily for industrial purposes. The first of these engines which was recently completed and passed successfully through its acceptance tests is illustrated on Plate XLI, which accompanies this issue. The engine is of the two-stroke type, single-acting, with three vertical cylinders, 390-mm. (15·35-in.) bore by 550 mm. (21·62 in.) stroke. It develops 300 h.p. to 400 h.p. at 160 r.p.m. to 200 r.p.m. The adoption of the two-stroke cycle system for an industrial engine of comparatively small power is of some interest. The event is not unique, but it has generally been held that two-cycle working is more suitable for large powers only. The Ansaldo-San Giorgio firm, which has been building two-cycle Diesels for ten years, considers that the question of size has no bearing on the two-cycle *versus* four-cycle question and that two-cycle engines are superior in any capacity. Many will, of course, disagree from this opinion, but it is interesting to note that the firm build two-cycle engines from 40 h.p. in two cylinders to 4,000 h.p. in six cylinders. Many of their two-cycle industrial engines of 120 h.p., 200 h.p. and 300 h.p. have been running for some years.

The general appearance of the new engine will be followed from Figs. 1 to 7, on Plate XLI, although

one of the main features of construction will not at first be apparent from these figures. As will be seen cast-iron side frames are bolted to the bed and carry the cylinders. These frames give a totally enclosed construction, large inspection doors being provided as is well shown in Figs. 1 and 4. The construction is reinforced by means of long forged steel columns which tie the cylinders to the bedplate and take the main forces. The upper parts of these columns with their securing nuts can be seen between the cylinders in Fig. 4, while the nuts at the lower ends of two of the columns can be seen in Fig. 5. The columns tie the whole structure together and transmit the explosion force on the cylinder direct to the bedplate. The cylinders have internal liners which are renewable and which are free to expand downwards. The arrangement can be seen in Fig. 6.

The distribution gear consists of a camshaft carried along the front of the engine and driven from the crankshaft by a vertical shaft, as can be seen in Fig. 4. This camshaft controls the starting valves and also the atomising valves. There are no exhaust valves, exhaust taking place through ports in the cylinder walls. The scavenging air enters each cylinder through a similar series of ports which are placed in front of the exhaust ports and are uncovered in turn by the piston. The inflow of scavenging air to the cylinder begins when the internal pressure is equal to, or less than, that of the scavenging air. The absence of exhaust arrangements on the cylinder head make it a comparatively simple part of the engine. It carries only the atomiser and the starting valve and a safety valve, the absence of exhaust valves leaving plenty of room for this latter item. The pistons are provided with cross-heads and are oil-cooled, the oil being introduced through telescopic pipes. The heated oil is discharged to a cooler; and its temperature is reduced before it goes into circulation again.

The scavenging pump, which can be seen in Fig. 4, is double-acting and is direct-driven from the crankshaft. It is controlled by a piston valve driven from an eccentric on the crankshaft. The suction of this pump takes place through a silencer, and the outlet leads to a reservoir cast with the framing under the cylinders. The main air compressor is of the three-stage type, with three superposed cylinders. It is provided with automatic valves and, as will be seen from Fig. 4, is direct-driven from the crankshaft. The compressor is of sufficient capacity to rapidly change the starting-air bottles. The fuel pump is controlled by the distribution shaft. It is provided with three cylinders, one for each working cylinder, and each pump cylinder has one inlet valve and two outlet valves in series. The fuel supply is regulated by keeping the suction valves open for a variable time during the delivery stroke. Regulation is controlled by a centrifugal governor on the vertical shaft. An important feature of the engine is the automatic regulation of the atomising air pressure in terms of the fuel supply. This is obtained by a device which ensures that as the quantity of fuel delivered to the cylinders is reduced, the suction intake of the air compressor is also reduced, and *vice versa*. This device, which has proved quite satisfactory in practical work does not interfere with the regulation of the air compressor by hand.

The engine is also fitted with a reciprocating pump for circulating cooling water, a reciprocating circulating pump for the cooling oil for the piston heads, and a gear pump for the forced lubrication of all main bearings. A sight-feed lubricator is fitted for the working cylinders and air compressor. The engine is designed from the point of view of all parts being easy of access for inspection or repair. The pistons can be removed either from above by taking off the cylinder heads, or below through the inspection doors.

*Table giving Results of Tests.*

| | | | | |
|---|---|---|---|---|
| Revolutions per minute .. | 163·8 | 162·9 | 162·2 | 161·5 |
| Horse-power .. .. .. | 32·7 | 162·9 | 260·0 | 323·0 |
| Consumption (lb. per hour) .. | 36·8 | 80·0 | 112·5 | 139·0 |
| Consumption (lb. per horse-power hour) .. .. | — | 0·491 | 0·435 | 0·430 |
| Thermal efficiency .. .. | — | 27·0 | 31·8 | 32·1 |
| Mean temperature of water inlet to cylinder jacket (deg. C.) .. .. .. | 14 | 14 | 14 | 14 |
| Mean temperature of water outlet from cylinders (deg. C.) .. .. .. .. | 25 | 35 | 42 | 47 |
| Exhaust gas temperature (deg. C.) .. .. .. | 120 | 180 | 245 | 300 |
| Pressure of scavenging air lb. per square inch) .. .. | 2 | 2 | 2 | 2 |
| Atomising air pressure (lb. per square inch) .. .. | 720 | 900 | 1,050 | 1,125 |

The first engines of this new model which were built were supplied to an electric generating station in South America. These are of 360 h.p., run at 160 r.p.m., and are each direct-coupled to a 200-kw. continuous-current dynamo. The electrical machines were supplied by the Stabilimento Elettrotecnico Geo. Ansaldo, of Genoa. We give above some results of tests which were carried out on these engines. The power was absorbed by a water dynamometer. The fuel used had a specific gravity of 0·905, a calorific value of 19,800 B.Th.U., and carried bituminous impurities to the extent of 25 per cent.

The results of these tests are plotted in Fig. 8, on Plate XLI, in which curves are given connecting brake horse-power with consumption in pounds per hour and pounds per horse-power hour. The full-load consumption of 0·43 lb. per horse-power hour is a very favourable figure in view of the fuel used. The builders suggest that this figure would not have been improved on by the four-cycle engine. The fuel could probably have been used in any Diesel engine, but the Ansaldo engines with which we are dealing have also been run on a fuel of 0·955 specific gravity and containing 70 per cent of bituminous impurities and 2·5 per cent, of sulphur. This oil is normally employed only for burning under boilers. With it the consumption was 0·442 lb. per horse-power hour, and the combustion was quite satisfactory. In Figs. 9 and 10, on Plate XLI, two indicator diagrams are reproduced The first was taken on overload, the engine developing 330 h.p. and the latter at 240 h.p. corresponding to about four-fifths full load. The mechanical efficiency of the engine has a value between 77 per cent. and 78 per cent. at full load. The speed regulation proved very satisfactory on test and the variation in passing from full to no load was in the neighbourhood of 2 per cent.

MELTING SNOW IN TURNTABLE PITS.—In clearing snow at engine terminals, the Canadian National Railways, according to *Engineering News-Record*, New York, have had very satisfactory results from the use of steam coils in turntable pits. These facilitate the operation of the turntable, and enable the pit to be used as a snow melter, into which is thrown the snow cleared from the yard and tracks, the water being carried off by the drains.

# GRAB DITCHING MACHINE.

CONSTRUCTED BY MESSRS. PRIESTMAN BROTHERS, LIMITED, ENGINEERS, HULL.

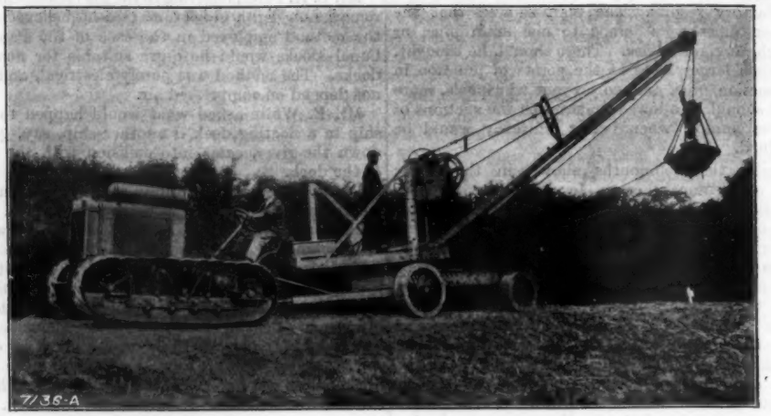



FIG. 1.

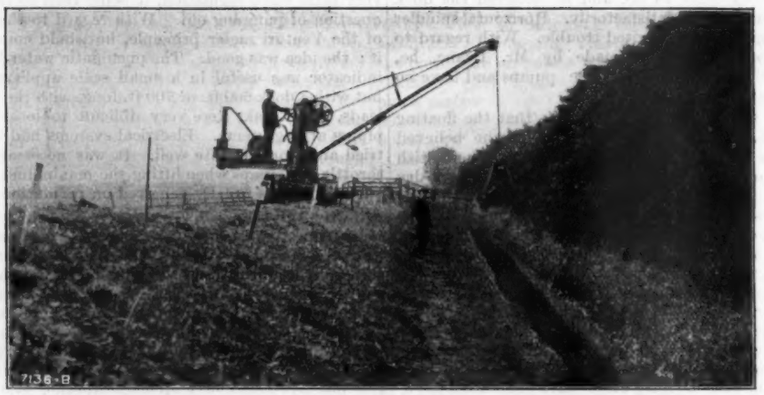



FIG. 2.

## GRAB DITCHING MACHINE.

IN order to encourage efficient methods of making and cleaning out ditches for agricultural drainage, the Ministry of Agriculture and Fisheries recently organised a demonstration of the capabilities of various types of machinery for the purpose. The demonstration took place at Aubourn Fen, near Harmston, in Lincolnshire, early in the present month, and among the machines entered was the grab-ditcher illustrated in Figs. 1 and 2 above. This machine was designed and built by Messrs. Priestman Brothers, of Hull, in collaboration with, and under the direction of, the Ministry, with the object of providing an economical means of cleansing drains, ditches and subsidiary channels. It consists essentially of a small portable crane operating a grab, and coupled to an agricultural tractor of the chain-track type. The tractor both hauls the crane along and provides the power for working it, the power transmission being through a shaft with universal couplings.

The crane has a gross weight of 4½ tons and is thus well within the hauling capacity of almost any tractor. It is fitted with an adjustable jib capable of working the grab at a radius of 20 ft., or at any less radius that may be desired. The grab can deposit the spoil either quite clear of the bank along which the machine runs, into a cart or other vehicle, or on to the bank itself should the latter course be desired. Its working range gives the machine a great advantage over hand labour, as men working in a ditch can only throw the spoil a very limited distance, and a second gang to shift it again may be necessary. The grab is easily controlled by one operator and can perform its full cycle of operations, namely lowering, grabbing, hoisting, slewing and depositing the load within 30 seconds. In a recent test, carried out under very disadvantageous conditions for the machine, a comparison was made

# 50-TON TWELVE-THROW CRANKSHAFT.

CONSTRUCTED BY SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, OPENSHAW, MANCHESTER.

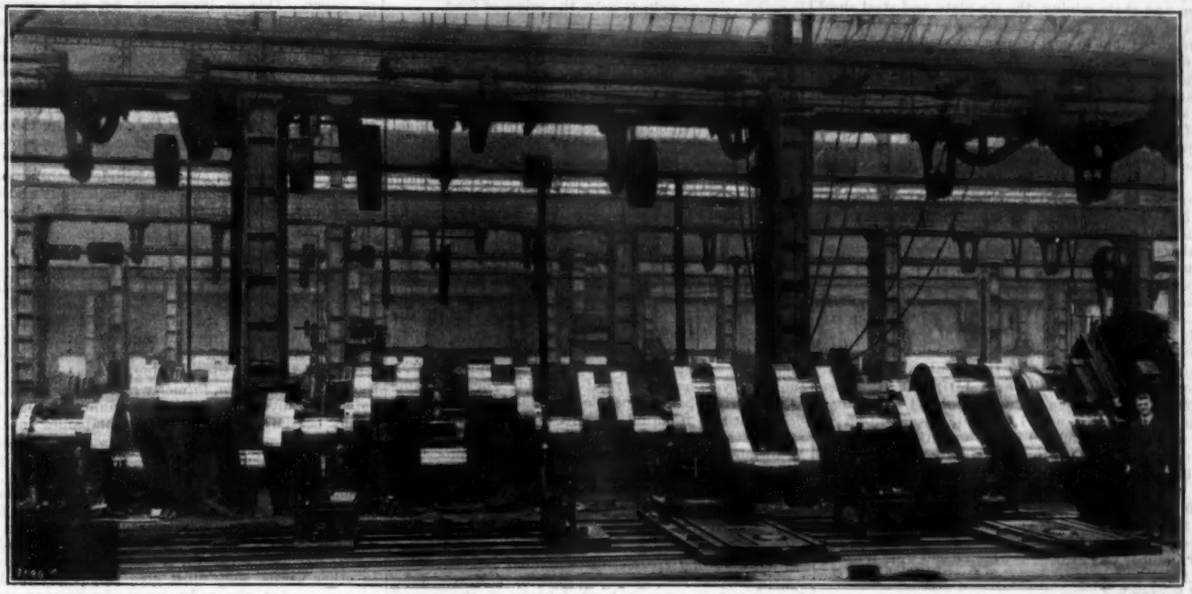


FIG. 1.

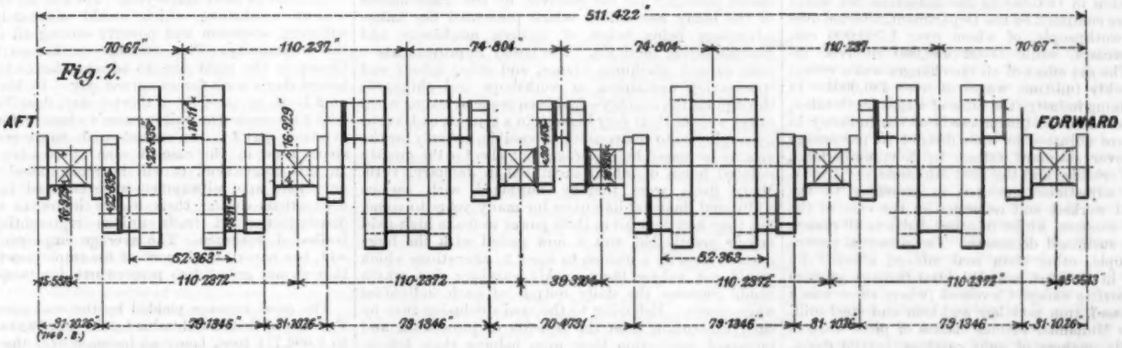



Fig. 2.

between the work of a gang of four men and that of the machine, and we understand that the following results were obtained:—

| | Manual Labour | Ditcher. |
|---|---|---|
| Number of men... ... | 4 | 2 |
| Cost per chain cleared ... | 15*s.* | 8*s.* 8*d.* |
| Number of chains cleared | 5 | 4 |
| Number of working hours | 8 | 4 hr. 56 min. |
| Estimated total volume lifted ... ... ... | 3,300 cub. ft. | 2,508 cub. ft. |
| Average volume per hour | 412·5 cub. ft. | 508·4 cub. ft. |
| Average time per chain... | 1 hr. 36 min. | 1 hr. 14 min. |
| Average time per ton lifted ... ... ... | 2·9 min. | 2·37 min. |
| Cost per ton ... ... | 5·45*d.* | 3·3*d.* |

The fact that the crane and grab can be attached to a tractor which is available for other purposes when the crane is not in use, makes the combination very advantageous for contractors, drainage authorities or large agriculturists. The distribution of the weight over a considerable length of track enables the machine to work on banks where a heavier wheel pressure would be inadmissible. Messrs. Priestman are now constructing a new type in which the crane is fitted with chain tracks and carries a much larger grab. Power will be obtained from an engine mounted on the footplate of the crane, so that the whole machine is self-contained, or alternatively a separate tractor can be used.

USBORNE MEMORIAL LECTURES.—A fund has recently been raised by private subscription to provide a small fee for an annual lecture in memory of the late Wing-Commander Nevill Usborne, who played an important part in the early development of British airships. The lectures will be delivered under the auspices of the Royal Aeronautical Society, the first being given in 1922.

## 50-TON TWELVE-THROW CRANKSHAFT.

THE above illustrations show one of two unusually complex crankshafts which are being constructed by Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, of Openshaw, Manchester, for internal combustion marine engines. They are being built to the order of Messrs. William Doxford and Son, Limited, of Sunderland for their well-known type of opposed-piston marine oil engine. In Fig. 1 a general view of one crankshaft set up in a lathe for inspection purposes is given, while in Fig. 2 the general features of construction are shown together with main dimensions. The shaft is built up of four sets of cranks, each of three throws, for the opposed piston working cylinders, and one centre crank for the scavenge pump. All are connected up by flanged coupling shafts. The total length of the complete shaft is 42 ft. 7·44 in. and it weighs 50 tons. As will be seen from Fig. 2, the main journals are 1 ft. 4·93 in. in diameter, and the crank pins are 1 ft. 6·11 in. diameter. The main crank throw is 1 ft. 10·235 in.

The finished shaft under inspection proved to be remarkably true and well within the limits of error allowed. The error in the total length was 0·008 in., and the maximum error in general alignment of all the journals did not exceed 0·0012 in. The average error in alignment of each separate length of journal in relation to general alignment was 0·0002 in. and the average error in alignment of crank pins in relation to general alignment of journals was 0·0003 in.

FILTRATION.—The papers discussed before the division of Industrial and Engineering Chemistry of the American Chemical Society in a so-called "Filtration-Symposium," are published in the November issue of the *Journal of Industrial and Engineering Chemistry*. All the papers were of American origin, except one by Mr. Eustace A. Alliott, of Westminster, on "Washing and Washing Ports in connection with Chamber and Frame Filter Presses," which was one of the most comprehensive contributions to the discussion. A great variety of papers dealt with various filter materials, modern lead type filters, the centrifugal filters and filter cells, the feeding of filters and other general problems; among special novelties were the Atkins-Shriver automatic filter press, which swings on trunnions, and the Vallez rotary filter, the perforated frames of which rotate with their shaft once in about 1½ minutes.

TENDERS FOR THE BRITISH TRADE SHIP.—The directors of the trade ship "British Industry," of which Earl Grey is chairman, announce that provisional tenders are being obtained by the builders of the ship for the various parts and fittings. Exhibitors who are in a position to supply some part or fitting as an exhibit actually in use on board, quite apart from their display in the exhibition proper, are naturally anxious to have their products accepted for this purpose. The examination of specifications is taking place at Wallsend-on-Tyne, where the ship will be built, and at the offices of the British Trade Ship, 12, Grosvenor Gardens, London. The examination is revealing that Birmingham wants its bedsteads in the best cabins; Kidderminster its carpets; Bradford its textiles, not only on show but in use; Sheffield its cutlery; and so on with hardware, machinery, leather, glass and electrical goods. These trades make up two-thirds of the total exports of the country. The crucial test which will apply in all cases is that of quality, and, unless an exhibitor can satisfy the builders that his product is of the highest, it will not be included as part of the structure or of the fittings of the ship. When full arrangements have been completed the names of the chief firms responsible for the various component parts of the trade ship will be published.

## INDUSTRIAL NOTES.

The Ministry of Labour state that employment in October continued bad generally, and there was much unemployment and short-time working in most of the principal industries. In certain trades, particularly in iron and shale mining, the tin-plate and steel sheet industry, and the textile trades, some improvement was reported, but in coal-mining, iron and steel manufacture, and the pottery trade, there was a further decline. The percentage unemployed among members of trade unions from which returns are received was 15·6 at the end of October, compared with 14·8 at the end of September. The percentage unemployed among workpeople insured under the Unemployment Insurance Act was 12·8 on October 28, as compared with 12·2 on September 30; the figures on which these percentages are based are exclusive of those persons who had removed their unemployment books after exhaustion of benefit. On November 4 the second special benefit period commenced, and persons who had exhausted benefit were able to make fresh claims, and the percentage at that date was 14·5. The total number of workpeople registered at the Employment Exchanges as unemployed on October 28 was approximately 1,611,000, of whom 1,252,000 were men and 263,000 were women, and the remainder were boys and girls. On September 30 the number on the live register was 1,405,000, of whom 1,078,000 were men and 229,000 were women. On November 4 the number on the live register was 1,729,000. In addition to those unemployed, 152,000 males and 100,000 females were registered on October 28 as working systematic short time in such a manner as to entitle them to benefit under the Unemployment Insurance Act. On September 30 the corresponding figures were 177,000 males and 145,000 females. The number of vacancies notified by employers to exchanges and unfilled at the end of October was 21,600, of which 6,300 were for men and 13,100 for women, compared with 21,000 at the end of September.

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Changes in rates of wages reported as having come into operation in October in the industries for which statistics are compiled by the Department, affected over 2,100,000 workpeople, of whom over 1,700,000 sustained decreases, while about 400,000 received increases. The net effect of all the changes was a reduction in weekly full-time wages of over 430,000*l.* In the coal-mining industry the rates of wages for October, which were based on the proceeds of the industry in August, were adjusted in each district to percentage advances over standard rates. In Northumberland, Durham, Yorkshire and the East Midlands and Lancashire the adjustment resulted in increases to the higher paid workers and reduction in the case of the lower paid workers, whilst in other districts all classes of workers sustained decreases. The principal groups of workpeople, other than coal miners, affected by reductions in October included blast-furnace workers in most districts except Cleveland (where there was a small increase), iron puddlers and iron and steel millmen in the Midlands, various classes of piece-workers in shipyards, makers of light castings, textile dyers, bleachers, &c., in Yorkshire, Lancashire and Scotland, and workpeople in the heavy chemical and other trades. Since the beginning of 1921 changes in rates of wages reported to the Department have resulted in a net reduction of over 4,370,000*l.* in the weekly wages of nearly 6,800,000 workpeople, and a net increase of over 23,000*l.* in the wages of nearly 130,000 workpeople.

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The number of trade disputes involving stoppages of work reported to the department as beginning in October was 64. In addition, 49 disputes, which began before October, were still in progress at the beginning of the month. The total number of workpeople involved in all disputes in progress at any time in October (including those thrown out of work at the establishments where the disputes occurred, though not themselves parties to the disputes) was about 25,000, as compared with 20,000 in the previous month, and 1,200,000 in October, 1920, when a dispute involving over 1,000,000 workpeople was in progress in the coal-mining industry of Great Britain. The estimated aggregate duration of all disputes during October was nearly 200,000 working days, as compared with 150,000 days in September, 1921, and with over 13,000,000 days in October, 1920. The estimated aggregate duration of all disputes reported as in progress during the first ten months of the present year was over 84,000,000 working days. The total number of workpeople involved in these disputes was approximately 1,700,000. In the corresponding period of 1920, nearly the same number of workpeople were involved in disputes having an aggregate duration of approximately 23,000,000 working days.

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On November 1 the average level of retail prices of all the commodities taken into account in the statistics prepared by the Ministry of Labour (including food, rent, clothing, fuel, light and miscellaneous items) was about 103 per cent. above that of July, 1914. This figure is the lowest recorded since July, 1918. The corresponding figure for October 1, 1921, was 110 per cent. The decrease in the percentage since October 1 is mainly due to reductions in the prices of food.

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The Engineering and the National Employers' Federation, and the Amalgamated Engineering Union have signed a provisional agreement on the subject of freedom of management. The agreement reads as follows:—

"The trade union shall not interfere with the right of the employers in the exercise of managerial functions in their establishments, and the federation shall not interfere with the proper functions of the trade union. In the exercise of these functions the parties shall have regard to the provisions for avoiding disputes of April 17, 1914, which are amplified by the shop stewards and works committee agreement of May 20, 1919, and to the terms of other national and local agreements between the parties. Instructions of the management shall be observed pending any question in connection therewith being discussed in accordance with the provisions referred to.

"It is agreed that, in terms of the overtime and nightshift agreement of September 29 and 30, 1920, the employers have the right to decide when overtime is necessary, the workpeople or their representatives being entitled to bring forward under the provisions referred to any cases of overtime they desire discussed. Meantime the overtime required shall be proceeded with."

A ballot on this agreement is to be taken by the men; It is also to be approved by the various associations of employers.

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An interesting speech was delivered last Saturday by Sir Thomas Bell, managing director of Messrs. John Brown and Co., Limited, Clydebank, at the annual dinner of the Glasgow and District Foremen's Mutual Benefit Society. Sir Thomas referred to Lord Weir's recent pleadings for the removal by the trade unions of the many restrictions which prevented the fullest advantage being taken of modern machinery and manufacturing methods. The costly improvements—such as new machines, cranes, and other labour and time-saving appliances in workshops and shipyards throughout the country—had been made at a time when prices were at their very highest, in a genuine endeavour by employers to compensate, if possible, not only for the greatly increased hourly wages but also for the greatly reduced hours of labour instituted in January, 1919. Many firms were thereby burdened with serious additional financial liabilities for many years to come, but they had done all in their power to make high-paid labour practicable, and it now rested with the large mass of sensible workmen to agree to alterations which would not reduce their weekly earnings, but which would increase the daily output of each individual wage-earner. Referring to the men's delusion that by their abstention from the benefits of piece-work and increased production they were helping their fellow-workmen to have more settled employment, Sir Thomas asked whether there was to be no increase in the world's trade. How would it be, he added, if employers took up a similar sentimental stand and refrained from extending and improving their works on the plea that if they did so they might injure those fellow-employers who had not the available capital to do likewise. In regard particularly to thrift, Sir Thomas said there seemed to be urgent necessity for the State extending some form of special encouragement to all manual workers who still remained self-supporting and self-respecting, and who, by self-denial, put by savings as opportunity offered. The annual rate of interest on National Saving Certificates taken out by manual workers and held by them might be increased from 5 per cent. to 7½ per cent. for a guaranteed period of ten years. There were also a large number of self-supporting and self-respecting, non-manual workers, who, besides, are non-clamorous; these latter ought in all justice to share in this contemplated boon.

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Mr. Robert Williams, the general secretary of the National Transport Workers' Federation, has returned from the Conference at Amsterdam of the International Federation of Trade Unions. He is reported to have stated that all organisations affiliated to the International Federation will carry on their propaganda against militarism and in favour of universal disarmament. In the event of imminent danger of war, the workers of all countries are to prevent the outbreak of hostilities by immediately proclaiming a general strike. These international labour conferences on purely political questions always seem to us an absolute loss of time; the labour leaders who attend them, at the cost of every union member, would be far better employed in endeavouring to solve the actual problems which are confronting the whole population of their respective countries. Moreover, there are labour leaders who attend such conferences who, in the event of threatened hostilities, would utterly fail to carry their men with them, since the latter would most certainly consider the voted resolutions as mere scraps of paper. This is borne out by past experience. The part now mainly played by most labour societies carries to our mind the action of many municipalities in capital cities and other large towns. These municipalities are exactly on the same plane as the municipalities of any small towns, yet they are frequently carried away by an undue sense of their own importance, and instead of devoting, as they should do, the whole of their activities to furthering the immediate interests of their ratepayers, they must needs spend their time discussing the Government's attitude as to, probably, "the open door in China," with the lengthy and futile proceedings culminating in a vote of censure on the Government.

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Mr. C. T. Cramp, industrial general secretary of the National Union of Railwaymen, addressed a meeting of railwaymen at Oswestry last Saturday, and said that in this great wave of trade depression railwaymen were no longer immune from unemployment. There had been a census of their branches, three-fourths of the returns had been made, showing between nine and ten thousand railwaymen, formerly regarded as permanent, out of employment. At the beginning of 1923 there would be only four main line companies in Great Britain, and possibly railwaymen would be asked to make modifications of service. There was one thing upon which they would not give way, namely, the principle of the 8-hour day, and an 8-hour day meant 8 hours honest work per day. If they believed 8 hours were too many, let them openly demand 7, or even 6 hours per day, but never use the principle of the 8-hour day as a cloak for 8 hours nominally worked. In other words, they must give two pennyworth for twopence. Let the railwaymen, he further stated, endeavour by competition to make the railways so remunerative that the companies could give the best conditions to their employees. He was no believer in violent revolution, which would ultimately create suffering, suspicion and poverty among all classes of the community. This attitude on the part of Mr. Cramp is the right one to adopt so far as regards an honest day's work for an agreed pay. In his plea for an 8-hour, or possibly a shorter day, does Mr. Cramp wish to increase the railwaymen's chances for earning overtime pay? He cannot wish to increase their spare time in the case of men at country stations. In this connection, it will be remembered that not very long ago railwaymen were engaged in various occupations during their leisure hours, to the great dissatisfaction of trade unions representing other bodies of workmen. The average employer, we may add, has never asked more of his employees than that they should give "two pennyworth for twopence."

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The gross tonnage yielded by the coal mines of the Province of British Columbia for the year 1920 amounted to 2,696,774 tons, being an increase over the previous year of 287,826 tons. These figures are quoted by the "Annual Report of the Minister of Mines for the Year ending December 31, 1920, being an account of Mining Operations for Gold, Coal, &c., in the Province of British Columbia." In regard to iron, the report states that, so far, no metallic iron has been produced in the province; the opinion, however, prevails in many quarters, that conditions are favourable for the establishment of an iron-smelting plant somewhere on the British Columbia coast, there being in the vicinity an adequate supply of magnetite iron ore. The report enters into the gold and silver production of the province. The production of copper was 44,887,676 lb., valued at 7,832,899 dols.; other figures were as follow: Lead, 39,331,218 lb., valued at 2,816,115 dols.; zinc, 47,208,268 lb. and 3,077,979 dols. The market has been dormant for molybdenite since the armistice, and the same may be said for chromite. There were shipped nearly 600 tons of manganese ore, running at over 50 per cent. manganese and less than 20 per cent. silica. The fatal accidents in and around coal mines during 1920 totalled 17 for a total number of 6,349 men, or 2·67 per 1,000.

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The secretary of the London Iron and Steel Exchange, Limited, states that the production of pig-iron is improving, and, although at the moment business in this department is poor, recent price adjustments are creating a sounder feeling in the market; the number of orders placed abroad has decreased considerably of late, and there is every likelihood of a reduction of imports of pig-iron from the Continent. At the same time there are still some heavy quantities to come forward against old contracts. Generally speaking, the home buyers of iron and steel are trading cautiously and only covering their immediate requirements. To

such an extent has this policy been carried that sellers complain that orders despatched one day are expected to be executed the next. One of the effects of this policy is to keep the mills short of orders, and a feature of the situation is that very few manufacturers can see their way clear for more than a few weeks ahead. The overseas demand is light, but it has been fairly well sustained. The principal buying markets continue to be the East, but there have been signs recently of a revival of business in the South American trade. In this market, both German and American competition has to be met; but as the British manufacturers gradually reduce their costs and prices they are beginning to regain a part of their pre-war position in markets that not so long ago appeared to be irretrievably lost. In this they are, of course, helped by the rather disorganised condition of the iron and steel trades on the Continent.

## NOTES ON NEW BOOKS.

Transition curves are a relatively modern development in railway practice, and were originally introduced in a more or less rough and ready fashion, the ganger putting in what he called "somethink of a parabola," where trains were found to ride roughly over curves. Of recent years the question has been very carefully studied by many competent engineers, and those who have this class of work to do will find "*The Transition Spiral*," by Mr. A. L. Higgins, a very useful text book. The volume is published at 6*s.* net by Messrs. Constable and Co., and, in addition to providing an adequate discussion of the theory, contains detailed and systematic field exercises showing how to deal with such problems as may arise in practice. These are apt to be somewhat more difficult when the question is the easement of an existing curve than when the surveyor starts with a clean sheet. The cubic parabola was at one time somewhat extensively used for such easements, but Mr. Higgins adopts the curve of which the equation may be written as $s = \frac{B}{\rho}$ where $s$ denotes a distance measured along the curve, $\rho$ its radius of curvature and B a constant

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The true nature of entropy gave rise to a lively discussion some twenty years or more ago. In practice it is commonly treated as equivalent to a specific heat, and it has certainly the same dimensions when expressed in terms of mass, length and time. Expressed in the same fundamental units temperature is of zero dimensions, from which since H and T $\phi$ are of the same dimensions, it follows that $\phi$, the entropy per unit of weight, must have the dimensions of a length, since H, the total heat of a body, is a quantity of energy divided by a weight, and is consequently of unit dimensions in length, and of zero dimensions in time and mass. On the other hand $\phi$ is proportional to the logarithm of the probability of the state of a substance. Since the available energy of the universe is continually being dissipated, the ultimate state to which every body is tending is one in which the available energy has been entirely dissipated, and in this case $\phi$ has its maximum value. Given an unlimited draft on the Bank of Time this state is more probable than any other, and the probability of any other state is proportional to $\epsilon^{\phi}$, where $\phi$ denotes the entropy. A physical conception of the meaning of entropy is thus obtained. An attempt to replace this concept by considering $\phi$ to be analogous to mechanical inertia is embodied in a small volume entitled "*Entropy as a Tangible Conception*," just issued by Messrs. Crosby, Lockwood and Son, at the price of 8*s.* 6*d.* The author is Engineer-Lieutenant-Commander S. G. Wheeler, R.N., who is one of the lecturers at the Royal Naval Engineering College, Keyham. At the best the attempt ranks with the complicated "simple proofs" of propositions in mechanics, which were to be found in the older type of text book and were prepared for students ignorant of the elements of the calculus. It has been well said that such proofs presented greater difficulties to the student than would the acquirement of a sufficient knowledge of the calculus to render them unnecessary. We fear that this will be found to be the case with the work under notice. As stated, the author attempts to draw an analogy between entropy and the mechanical inertia of a body, but admits that the analogy "is somewhat far-fetched and occasionally not quite accurate." For our own part his conception seems much more difficult to understand than an orthodox presentment of the subject would have been; and whilst mechanical models are often valuable as indicating new lines for research, it is difficult to believe that the author's mechanical model of a heat engine will ever prove serviceable in this way. Of course, mechanical models of heat engines are not new, and Osborne Reynolds devised an extremely ingenious one, which was described in a lecture delivered to the Institution of Civil Engineers in 1883, and reprinted in vol. ii of his "Scientific Papers."

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The mathematical attainments of those matriculating at our various engineering colleges are generally somewhat moderate, and we believe that this is also the case in America. Text books for engineering students have accordingly to be written with this limitation in view. Indeed, many of the graduates from these colleges would, we imagine, be unable to read with profit a work requiring a knowledge of the properties of partial differential equations. The average student whose ambitions in this regard are restricted, will find his needs very well met by the elementary treatise on "*Thermodynamics*" which has recently been published at 18*s.* net by the McGraw-Hill Company, Inc., of New York and London. The author is Professor J. E. Emswiller, and he explains clearly and adequately how to make such thermodynamic calculations as are required in the design of the different types of heat engines and refrigerating plants. Most chapters have appended to them a well-selected series of problems, by which the student can test the growth of his knowledge, and it may safely be said that when he has worked through these he will find himself with a very fair grasp of the principles of the science, and in a position to tackle more advanced works should his tastes tend that way. The volume is written on strictly orthodox lines, and contains no reference to the difficulties that have been met with, in reconciling theory and experiment in the matter of the discharge of steam from nozzles. In fact the student is nowhere informed that in certain cases the weight of steam discharged from a nozzle is in excess of that theoretically possible by the formulas given by the author, who is, it would appear, totally unaware of the important discussions to which this anomaly has given rise during the past eight years. Moreover, the student receives no warning that in many steam tables the total heats and specific volumes tabulated are mutually incompatible. Apart from these blemishes, which should be remedied in another edition, the work under notice should well satisfy the requirements of the average student.

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One frequently has occasion to think that the man who may have charge of the running of a small plant, the foreman or the charge hand is too apt to rely for any knowledge of his job on such information as he may acquire in his practical experience, or to such as he may pick up more or less casually in conversation. The average busy working man of this type has usually neither time nor inclination to attend the various technical classes which all over the country cater for his needs. He looks upon these as fit, and as intended only, for boys. It would be well, however, if a larger proportion of such men would at least possess themselves of one of the many small practical books which are now available and which cover so many branches of work. Mr. Frank Broadbent's "*Dynamo and Motor Attendants and Their Machines*" is a book of the kind we have in mind. It is a practical instruction book, and contains just such theoretical explanation as is necessary to make the practical matter intelligible. It would be of much value to any intelligent working electrician. Mr. Broadbent's book is well known, and that it at least has not been unduly neglected is shown by the fact that the present edition is the tenth. A greatly extended circulation of the book would be, however, to the advantage of many workmen. It is published by Messrs. S. Rentell and Co., Limited, of 36, Maiden-lane, Strand, W.C. 2, and the price is 4*s.* 6*d.* net.

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Toothed gearing in its numerous varieties is now so important a component of machinery that its design and manufacture have become a specialised branch of mechanical engineering. Information on the subject will be found in most text books on mechanical design, but modern practice in gearing is generally far ahead of the text books, which moreover cannot afford the space to deal at all fully with the matter. In "*Gears and Gearing*," by Captain S. Bramley-Moore, M.C., M.I.Mech.E. (Percy Lund, Humphries and Co., Limited, Bradford; price 12*s.* 6*d.* net), the author has covered the subject in a very thorough manner, and the book should appeal to all who wish to know how modern gearing is designed and made. Much of the information is now published for the first time, and we may mention in particular a simple and accurate method of calculating spiral gears. The design of involute teeth has been worked out from a new point of view, and charts are presented showing the ratio between sliding and rolling for all combinations of gear teeth from 10 to 500 with pressure angles of 14½ deg. and 20 deg. respectively. The formulæ given for involute teeth are the outcome of the author's practical experience, and chapters on worm gear, hob design and measurement of gear teeth all likewise contain new and original data. The book is in no sense a rehash of old facts and formulæ, but a comprehensive treatise on modern gearing which will be studied with interest and advantage by all engineers who have to do with spur, bevel, helical, or worm gear.

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The choice of a book on scientific or technical subjects is too often a haphazard selection from among those which may happen at the moment to be stocked on the shelves of some easily accessible bookseller, and the best book, which may at the moment be out of stock runs the risk of being overlooked. The British Science Guild, of 6, John-street, Adelphi, has thus done a very considerable service in producing, at the moderate price of 10*s.*, a "*Catalogue of British Scientific and Technical Books*," which it is claimed covers every branch of science and technology. The effort is apparently the outcome of the interest aroused at the British Scientific Products Exhibition of 1918, when a collection of technical books was displayed. A very able committee has been responsible for the list now compiled, but no classification based on merits has been attempted. It will be recognised that such an attempt would lead to invidious distinctions and even erroneous conclusions, as a book may be valuable and helpful to one student for quite other reasons than those for which it may appeal to another. The information given is nevertheless likely to be of considerable assistance, as it includes price and date of last edition, and other particulars helpful in making selection. Some 6,000 works are classified in about 50 main groups, while complementary indexes of authors' names and subjects add to the service which the list can be put to. The volume includes only British works or British translations of foreign books. While it is recognised that this is by no means the only country producing useful text books, and that many of our technical books are not always of the standard they might be, the list undoubtedly comprises a large number of instructive works. It is proposed to revise the work annually, and we trust that the support accorded to the enterprise which has gone to compiling it, will suffice to warrant the keeping it continually and accurately revised.

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The latest developments of the Westinghouse brake, used in connection with the exceptionally big loads hauled on some railroads in the United States, is known as the double capacity brake. This, however, is not in general use, and the more ordinary forms therefore as yet have the wider interest. The "E.T." air brake, which was developed to meet the demand for a brake combining independent engine and tender braking with dependable automatic action working with the train is largely adopted now in America. It is well described in an attractive little book recently to hand, by W. W. Wood. This book, published by Messrs. Page and Co., 11, Gower-street, London, at 12*s.* 6*d.*, under the title of "*The Westinghouse E.T. Air Brake Instruction Pocket Book*" is really an English edition of a well-known American work. It is copiously illustrated by plates, and figures in the text. The former, about two dozen in number, are all in colour, each tint denoting a different pressure value so that the conditions for various applications may be readily followed. The book throughout deals with locomotive equipment. The brake as used in many countries outside America is also well described in a book of about 80 octavo pages, published by the Locomotive Publishing Company, Limited, 3, Amen Corner, E.C. 2. This book is entitled "*The Westinghouse Air Brake*," and is published at 2*s.* 6*d.* net. It will give readers in this country a very good idea of the brake mechanism, including both locomotive and train equipment, and while it makes no pretence at the detail of the work previously referred to, will be of considerable assistance in unravelling the mysteries of the triple valve, &c.; it also gives more information on air pumps and so on. A chapter is specially devoted to the brake as fitted to electrically propelled vehicles, and another to brake rigging. Both volumes suffer to some degree from poor arrangement, and could be improved by some elaboration of the introductory matter on the advantages and functions of the respective models now in service.

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Port Construction at Rio de Janeiro.—The Department of Overseas Trade, 35, Old Queen-street, S.W. 1, has received a telegram from the Commercial Secretary to H.M. Embassy at Rio de Janeiro to the effect that there is published in the *Diario Official* of November 12, by the Federal Inspectorate of Ports, a call for tenders to be presented by January 10, 1922, for the construction of a port, with 600 m. of quay, on Governors Island, Rio de Janeiro, this being part of a general scheme for creating a free zone. The value of the tender is estimated at 375,000*l.* Communications should be addressed to Chefe Exmo. Sr. Dr. Engenheiro Chefe, Inspectoria Federal das Obras do Porto, Rio de Janeiro, Brazil.

## A DRUM-TYPE STARTING PANEL FOR ELECTRIC MOTORS.

THE face-plate type of starter which is almost universally used for direct-current motors has in general proved a reliable and satisfactory article, but it none the less labours under an inherent disadvantage which becomes more serious as larger powers and heavier duties have to be met. This disadvantage lies in the fact that it depends on the pressure of a laminated copper brush, or similar contrivance, to obtain effective contact at each resistance step. This pressure, on which contact depends, cannot be high since any considerable amount would not allow the starter arm to be pulled back by the return spring on failure of supply, or similar eventuality. This inherent feature becomes, as we have said, a greater disadvantage as capacity increases, and as a result attention has been directed to the possibility of constructing drum starters.

It is obvious that although a very effective contact may be obtained with a drum such as is used in controller service there will remain the difficulty of arranging a satisfactory spring return if a simple drum arrangement be adopted. The problem is thus one of some difficulty, and the very ingenious solution of it put forward by Messrs. Brook, Hirst and Co., Limited, of Chester, in their new type of drum starter is of much interest. The starter embodies spring-controlled fingers which are self-aligning, and of which the contact pressure may be individually adjusted, while the drum is ground with the copper segments in position so that the latter form part of a true cylinder and give even contact with the fingers. The drum and assembled contacts are shown in Fig. 1, annexed, while the fingers are shown in Figs. 2 and 3. These latter embody a special feature in the fixing of the contact blocks. Normally blocks of this kind have a blind tapped hole at the back to receive a fixing screw, but in the Brook, Hirst finger the blocks are formed with a horizontal tapered slot at the back, into which the squared countersunk head of a fixing bolt slides before assembly. The bolt is finally secured by a nut. The whole arrangement will be clear from Figs. 2 and 3. One advantage of this method of fixing is that a greater depth of metal of the blocks is available for wear.

The essential feature of this new starter is contained in the drum operating mechanism. The starting handle, which is shown in Fig. 4, below, is of the makers' ratchet type, and has only one direction of rotation. This handle, in conjunction with the control switch which it actuates, and which can be seen to the left of Fig. 4, embodies three important features. The first of these is that if the starter is left in an intermediate position, the circuit is immediately opened. This effect is brought about by the free handle feature of the mechanism. To ratchet the drum forward the handle is brought from a downward position into an upright one. This closes the control switch, and if the handle is released it falls to its normal position and the switch is opened. In the "full on" position, and in that position only, an auxiliary drum contact provides continuity of the circuit independent of the control switch, and so allows the handle to be released.

The second feature of the operating mechanism is that the drum is returned to the "off" position by a single forward movement of the handle. This does not mean that the starter may be inadvertently put to the "off" position immediately it has been put to the "on" position, since the ratchet mechanism provides a definite check when the "on" position has been reached. After the handle has been released, however, a single forward movement puts the drum to the "off" position, and it is not necessary to ratchet the handle back through the intermediate steps. The third feature of the operating mechanism to which attention may be directed is that it provides a definite slow-motion operation. This is inherent in the ratchet action since the pawl fails to engage if the handle is operated too quickly. The mechanism, however, also includes a stop which prevents the drum over-running and consequently cutting-out more than one step of the resistance at a time.

This drum starter has been made the central feature of a series of ironclad motor panels, of which two examples are illustrated in Figs. 5 and 6, on page 727. A large variety of arrangements of such panels are, of course, possible, but in general they will embody a double-pole circuit-breaker and a double-pole isolating switch in addition to the starter. Reversing switches and shunt regulators may also be fitted. In any arrangement the double-pole circuit breaker consists of two electrically-operated contactors acting in conjunction with adjustable overload trips. The main current is always broken on these contactors and never on the starter. This applies whether the circuit is interrupted as the result of an overload, voltage failure, interruption of the starting operation, or the opening of the circuit by stop button control.

## DRUM-TYPE STARTING PANEL.

CONSTRUCTED BY MESSRS. BROOK, HIRST AND CO., LIMITED, ENGINEERS, CHESTER.

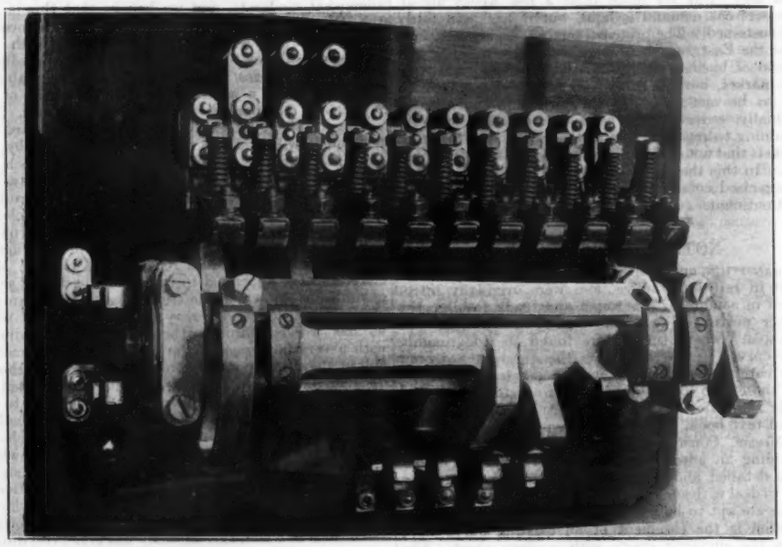


FIG. 1. COMPLETE STARTER, WITHOUT HANDLE.

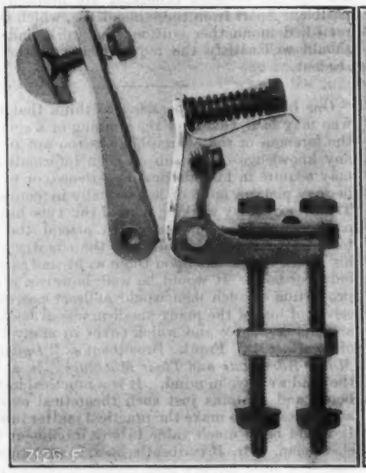


FIG. 2.

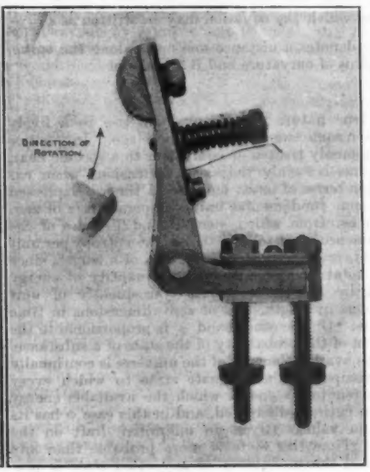



FIG. 3.

FIGS. 2 AND 3. FINGER CONTACTS FOR STARTER.

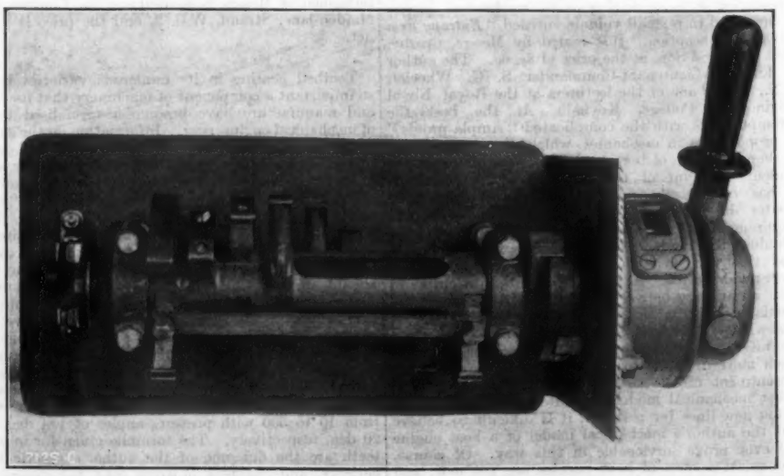


FIG. 4. STARTER BARREL AND OPERATING HANDLE.

# DRUM-TYPE STARTING PANEL FOR ELECTRIC MOTORS.

CONSTRUCTED BY MESSRS. BROOK, HIRST AND CO., LIMITED, ENGINEERS, CHESTER.

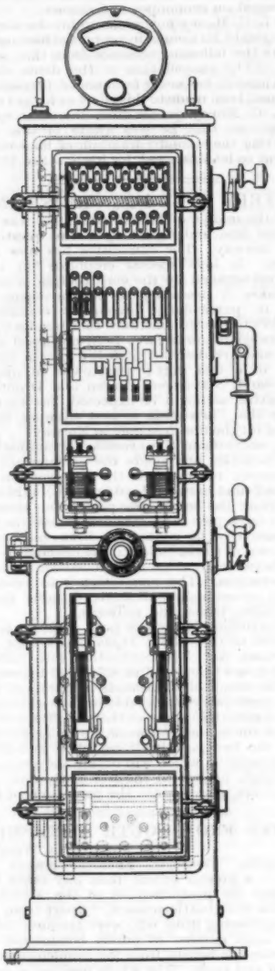


FIG. 5.

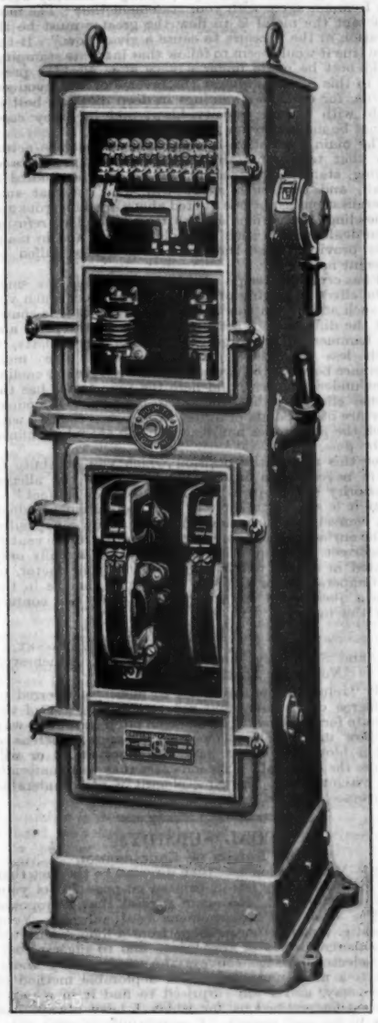


FIG. 6.

FIGS. 5 AND 6. ALTERNATIVE PANEL ARRANGEMENTS.

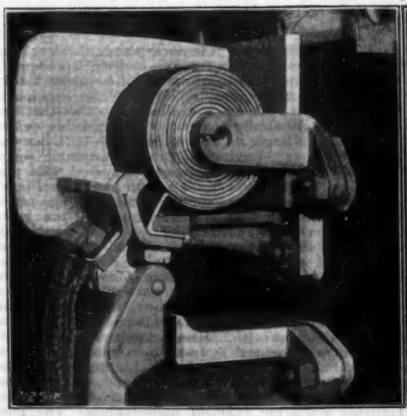


FIG. 8. CONTACTOR, CONTACTS CLOSING.

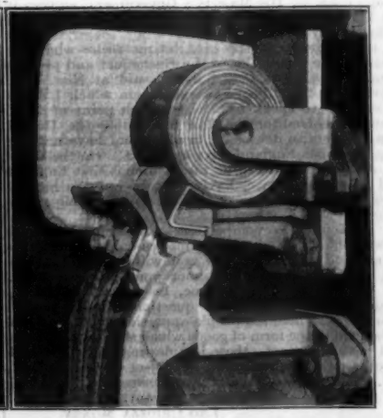


FIG. 9. CONTACTOR, CONTACTS CLOSED.

FIG. 7. CONTACTOR.

The contactors are electrically interlocked with the starter so that they cannot close the circuit unless the latter is in the "off" position.

One of two contactors is illustrated in Fig. 7, while views of the contacts with one of the arc shields removed are given in Figs. 8 and 9. The contacts are of hard-drawn copper of the solid butt type, and their action during closing ensures a long wearing period. As the contacts close there is a rolling action between them, as is illustrated in the two positions shown in Figs. 8 and 9. The contact springs are of steel, copper plated. A weak pressure, insufficient to give proper contact, is not possible. Since even when the supply voltage is low, if it is high enough to bring the contactor to the initial position, as shown in Fig. 8, then the increased magnetic pull due to the forward movement of the armature will be sufficient to close the contacts completely against the pressure of the spring. When the contactor is breaking circuit the rolling action of the contacts is reversed, so that the arc is broken at the initial position of contact and not at the final position. Consequently any arcing on breaking circuit does not affect the quality of contact at the point at which it is maintained. The contactors are fitted with magnetic blow-outs, while the balance of the moving part is such that it does not rebound, so that there is no tendency to draw out the arc.

The motor starting and control panels are arranged so that inching may be carried out to any extent. The inching may be controlled either from the starting handle or from special inching buttons. In the first case inching takes place from the "start" position, and in the latter in the "off" position. In both cases the full starting resistance is necessarily in circuit. In order, however, to permit of adjustment of the speed when inching, links and terminals are provided so that the value of the starting resistance, and consequently the starting current, may be varied. In addition to the inching arrangements several stop buttons may be fitted, which makes the whole starting

panel a very convenient one in use. The starting resistances have the standard full-load 1 minute rating, but they have been designed on very generous lines. Grid resistances are used in the larger sizes, but in the smaller a tubular form of resistance has been adopted. These consist of wire of a non-rusting alloy wound on an insulating tube with heat-resisting properties. After winding the whole is covered with cement. The tubes are fixed vertically and the through draught obtained gives high heat-dissipating power.

## AN EARLY STEAM TURBINE LOCOMOTIVE.

In our issue of September 30, page 477, we gave a short account of what is claimed to be the first steam turbine locomotive. This engine was produced in 1908 by the Societa Anonima Officine Meccaniche, Milan, being in fact an old shunting engine which was modified for the purpose in accordance with designs by Professor Belluzzo. It has been recently dismantled. As an interesting development to record we illustrate it in Figs. 1 and 4, page 730. The boiler had a heating surface of 30 sq. m. (323 sq. ft.) and it generated steam at a pressure of 10 kg. (142 lb. per square inch).

When fitting the steam turbines the original three axles—on which the locomotive was mounted—were replaced by two, and as thus modified the total weight was 26 tons. Each axle was driven through reduction gears by two turbines, one on each side, making four in all, through which the steam passed in series.

The boiler steam was led to the first turbine, which was fitted on the right-hand side over the leading axle, and the exhaust from this turbine was led to the turbine on the same side of the engine, but mounted over the trailing axle. Thence the steam passed to the corresponding turbine on the left-hand side of the engine and ultimately passed through the fourth turbine over the leading axle on the left-hand side, to the blast pipe.

The view of the locomotive, Fig. 1, shows the two turbines on the left-hand side, and also the method of suspension adopted and the flexible pipe connecting the two turbines. Fig. 2 is a vertical section through the high-pressure turbine; the others are similar in pattern, with the exception of the steam ways and blading.

Each turbine consisted simply of one velocity-compounded wheel carrying three rows of blades. Incorporated with the main blades was a "reverse" section which was used when the locomotive had to move backwards. The reverse blades were formed on the outer ends of the main blades (Fig. 4), and reversing was effected by cutting off the steam from the main or ahead rows of blading and directing it through an independent set of nozzles to the "reverse" sets of the blading. The arrangement is shown diagrammatically in Fig. 3. In forward running, the steam was admitted at A and discharged at B; whilst when reversed, the steam entered at C and escaped at D. Each turbine had two sets of nozzles for forward running, designed respectively for maximum speed and half speed, and also a third for running backwards.

The supply of steam to the nozzles was controlled by cylindrical valves, of which three were necessary for each turbine, namely, one for each of the ahead sets of nozzles and one for supplying the "reverse" nozzles. The valves for the four turbines were linked together, so that all were operated simultaneously. There were three control levers corresponding with the different sets of valves. The shaft of each turbine was fitted with a pinion gearing with a spur wheel keyed on the locomotive axle, the ratio of reduction being 8 : 1; at maximum speed the turbines ran at 2,400 r.p.m.

It is stated that tests made in actual service showed that to start under load required no more steam than was used with a reciprocating engine, and that the steam consumption in ordinary working was about the same for both classes of engine.

Designs have since been got out for a 1,500-h.p. locomotive, using superheated steam and an air condenser. This design is for a six-coupled engine with bogie in front and a Bissel truck at the trailing end. The gear casing is in the centre under the boiler, and the turbines, which are rigidly fixed to the frame-plates, drive through double reduction gear a lay shaft working the three axles by connecting rods. This locomotive would weigh about 70 tons and it is estimated that the fuel consumption would be about half the present figure for a corresponding locomotive of the usual type, as the air-cooled condenser fitted would, it is expected, maintain a vacuum of 28 5 in.

DEVELOPMENT OF THE PORT OF ORAN.—The British Vice-Consul at Oran has reported to the Department of Overseas Trade the proposals put forward by the local Chamber of Commerce at its general meeting held on October 4, for certain works to be undertaken for the extension of the port of Oran. The whole of the quays and warehouses of the port of Oran are the property of the local Chamber of Commerce, which has practically constructed the port and quays at its own expense, by loans authorised by the French State and with certain allowances supplied by the Government General on behalf of the Colony of Algeria.

## THE FLOW OF METAL DURING FORGING.

TO THE EDITOR OF ENGINEERING.

SIR,—I am much gratified that you thought my paper on the "Flow of Metal during Forging," read before the Manchester Association of Engineers, worthy of such careful comment in your last issue.

With a great deal of what you say I heartily agree, but I cannot agree with your statement that "The more reluctant the metal is to flow the greater must be the duration of the pressure to cause a given flow." If this were true it would seem to follow that intricate stampings could best be made under a very slow working press, but in this instance almost the reverse of what you say is true, for difficult stampings in deep dies can best be made with a high velocity blow, and in many cases cannot be made under a press at all.

The main contention of the paper is that the actual flow that takes place in all the various processes of forging, stamping, extruding, &c., should be studied in detail, and that such study will show us that such generalisations as the one quoted above are dangerous and misleading, the various actions that take place refusing to be dealt with in such a simple manner, and in many cases proving to be the same in processes called by different names.

It has certainly been a surprise to me to find how small is the effect in forging of the time factor, on which you lay such stress. In this and in other points it is shown that the difference in actual *flow* between the press and the hammer, when forging between plain palletts, is much less than is generally supposed. The main difference between the two seems to be the greater cooling effect under the press, and here the time factor has the reverse effect to that suggested by you. Of course, there are other points of difference between the two with which the paper does not deal, it being entirely confined to the *flow*.

For this reason the position which you attribute to me is never taken in the paper—"that the alleged superiority of the press has no foundation in fact"—What it is sought to show is that the statement which you, yourself, repeat in substance that a blow is expended on the surface whereas pressure penetrates to the centre, is incorrect. The question of penetration is really only affected in a very minor degree by the time factor, or the temperature, or the size of hammer, and is in the main a question of the width of the pallett in contact with the metal.

Yours faithfully,
HAROLD F. MASSEY.

B. and S. Massey, Limited, Openshaw, Manchester, November 22, 1921.

[By "reluctance of the metal to flow" we referred to its degree of viscosity and not to the intricacy of the ultimate form desired. A block of pitch or sealing wax will flow under a long-continued pressure, whereas a sudden blow will either have no effect at all or will rupture the material. This indicates that with materials in a viscous state, the time elemnt is of considerable importance.—ED. E.]

## COAL SUBSIDY.

TO THE EDITOR OF ENGINEERING.

SIR,—My attention has been directed to the fact that in a footnote to my letter, printed on page 567 of your issue of October 21, you again suggest that I proposed (in *The Observer*) a permanent coal subsidy. Your method is to select one passage from a long, connected and coherent series of statements and to suggest that, that selected passage conveys the whole of my views. That is a most undesirable and deplorable method of controversy, and I am surprised to find it in a paper of scientific pretensions for which I have always had great liking and respect. I respectfully suggest that, as an alternative, you might join with me in denouncing the extravagantly bad engineering practice which obtains in so many of our mines, and call, as I do, for a national inquest into the energy question.

I observe, too, that you term the proposal to cancel out the international war debts "silly" and "dishonest." But concrete proposals on the subject were long ago made by His Majesty's Government, so that it is the British State which you in effect accuse of silliness and dishonesty.

As to the merits of the case, let me recite what Mr. McKenna, late Chancellor of the Exchequer and present chairman of a great British bank, said at New York on November 2: "This is a subject on which I could only venture to speak from the British point of view. We are large creditors, and in relation to the United States we are also debtors. As a debtor I have nothing to say save that England pays her debts. On the other hand, speaking as a creditor, my opinion is that England would be selfishly wise, having regard only to her industrial and economic position, to remit the obligations due to her."

Mr. McKenna also pointed out to America that "the only way the indebtedness to America could be met was in goods, and these America was unwilling to receive."

Mr. McKenna has indeed met your case precisely. I see that on his return home, he says (*The Times*, November 11): "Where the question is understood—that is to say, where the people appreciate that they can only be paid in the form of goods which the United States would have to accept—there is a desire either to cancel the debts or to make them the subject of bargaining." Quite. "*Where the question is understood.*"

Your obedient servant,
LEO CHIOZZA MONEY.

November 14, 1921.

[Sir L. C. Money again shifts his ground and makes another unfounded charge. We have never suggested that he wants a permanent coal subsidy. Nor is he correct in his statement that we have misrepresented his views as published in *The Observer*. His original contention was that the taxpayers should be called upon to contribute a sum which he estimated at 45,000,000*l.* a year as a subsidy to the coal industry for some indefinite period. In our article of October 21, we quoted his own words at considerable length and gave his argument, such as it was, fully and clearly, as our readers will remember. His subsequent letters in no way alter our views as to the essential unsoundness of the opinions he has expressed on economics and finance.

As Sir L. C. Money now seeks to invoke the authority of Mr. Reginald McKenna, in support of his views, we may also quote the following sentence from that gentleman's speech: "The cancellation of the debts due by the United Kingdom has never been under discussion, nor has any proposal been made to this effect so far as I am aware." As Sir L. C. Money quotes from the same speech, it is fair to assume that he was aware of this statement, when writing the second paragraph of his letter, and we are content to let this speak for itself.—ED. E.]

## A FREE PORT FOR CHRISTIANIA.

ABOUT the middle of 1919 a committee was appointed to examine into and report upon the question of free ports in Norway. The committee has now completed its report. It lays special emphasis on the heavy expenditure entailed by the construction of such ports, which makes it necessary to confine them to places situated in particularly favourable conditions. The report refers to the circumstance that besides Christiania, other Norwegian towns have been discussed as suitable localities and are desirous of being chosen for the construction of a free port; the towns in question are Christianssand, Stavanger, Bergen and Drontheim, but the committee, as might be expected, has arrived at the conclusion that Christiania is best situated, and should be selected for the first free port in Norway.

Having undertaken the necessary examination of the different localities and made the calculations required, it unanimously recommends the construction of a free port in the Sound between Lindöen and Nakholmen, with entrance from the south, the port being closed on the north side by a pier from Lindöen across the Galteskör to Nakholmen. The connection between the free port and the town of Christiania will be effected by filling up the gaps between Lindöen and Hovedöen, and the latter and Vippetangen. This connection is to have sufficient breadth to accommodate all kinds of traffic, foot passengers, carriages, trams and railways.

The construction of the free port, at prices now ruling, is calculated to cost about 31,000,000 kroner, exclusive of warehouses, &c. The connection with railway lines, bridges, &c., are calculated at 8,750,000 kroner. As the State is the owner of the islands in question, which are bound to appreciate considerably in value through the free port, the committee proposes that the State shall defray the cost of the connection work, up to 7,000,000 kroner, and that the free port itself be taken in hand by the City of Christiania, which will obtain the necessary areas free of charge, subject to the free port, after the lapse of eighty years, passing into the possession of the State.

## NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

*The Cruiser Contracts.*—Sheffield stands to lose, probably to a greater extent than any other industrial centre, from the postponement of the Admiralty contracts of the four battle-cruisers. Apart from the three leading engineering firms who were favoured with direct orders, a large number of purely commercial concerns were expecting to benefit from the supplementary supply of material and tools. The whole position is now in the melting pot, and Sheffield is faced with an addition of between 5,000 to 10,000 to her total of 40,000 unemployed. Expensive plant specially maintained for armament construction is again thrown idle. Though no official pronouncement is yet forthcoming, it is expected that compensation will be afforded to assist the firms affected to tide over the compulsory period of inactivity. The development will probably bring to a head the subject of the provision of an increased Government subsidy for the maintenance of special equipment.

*Iron and Steel.*—As was anticipated, the levelling of home and foreign rates for iron and steel products has resulted in an increased number of inquiries for local materials of guaranteed quality. While nothing like sufficient new business is available to offset the loss of the British Admiralty contracts, unmistakable evidence is shown of a larger influx of orders from both home and foreign buyers. Engineering plant is running roughly at one-half its normal capacity, compared with about one-third of that capacity a month ago. Steel-makers are benefitting from the supply of cheap foreign pig-iron and an abundance of British scrap, and are looking to a further reduction in coke rates, with the possibility of additional concessions from railway companies. Several of the largest engineering concerns in South Yorkshire are expanding their foreign connections. Messrs. Hadfields, Limited, have joined with the Australian Electric Steel Company, Limited, in a large enterprise for the expansion of electric steel production in the Commonwealth. Messrs. Cammell Laird and Co. are similarly engaged in India in conjunction with the United Steel Corporation of Asia, Limited. Both these developments will necessitate the provision of a heavy tonnage of engineering plant, and this will doubtless provide work for Sheffield undertakings. The motor industry is taking larger supplies of steel and fittings, but makers of agricultural machinery, failing to induce any improvement, are branching out in other departments

of the machinery trades. The tool trades would benefit materially from an extension of export credits. Meanwhile there is an increasing demand for stainless steel goods. The new rustless iron is finding its way into the market in the form of small articles and fittings. A big future is prophesied for this discovery if the consideration of cost can be suitably adjusted.

*South Yorkshire Coal Trade.*—Business generally has taken a turn for the better. Many of the pits in the South Yorkshire area are now working practically full time, having disposed of stocks at cheap rates. Best steams are going away fairly well, but from the colliery standpoint are not fetching anything like a fair price considering the cost of production. Quotations for home manufacturing needs show weakness in sympathy with shipping rates. A slight improvement is reported in slacks, but there is little business passing either in cobbles or nuts, and furnace coke at reduced prices fails to attract many buyers. The recent expansion in business in house coal is maintained, but trade is not yet up to the normal for this time of the year. Quotations:—Best branch handpicked, 39*s.* to 40*s.*; Barnsley best Silkstone, 38*s.* to 40*s.*; Derbyshire best brights, 35*s.* to 36*s.*; Derbyshire best house, 34*s.* 6*d.* to 35*s.*; Derbyshire best large nuts, 30*s.* to 32*s.*; Derbyshire small nuts, 27*s.* to 29*s.*; Yorkshire hards, 29*s.* to 30*s.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; rough slacks, 17*s.* to 18*s.*; nutty slacks, 15*s.* to 16*s.*; smalls, 5*s.* 10*d.*

## NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

*The Cleveland Iron Trade.*—Output of the better qualities of Cleveland pig-iron continue on a very limited scale, but it is more than sufficient to meet very small needs. No. 1 is 115*s.* and No. 3 G.M.B. is 110*s.* for home consumption, and 5*s.* above these rates rules for shipment to foreign ports. The commoner kinds are abundant and difficult to dispose of. Both for home purposes and for export No. 4 foundry is 105*s.*, No. 4 forge and mottled are each 100*s.*, and white iron is 97*s.* 6*d.*

*Hematite.*—East Coast hematite is quite plentiful. With production far from fully absorbed, stocks are accumulating. Makers are very keen to secure orders, to which end they are prepared to make rather considerable price concessions. Nos. 1, 2 and 3 are offered very freely for export as well as for home consumption, and No. 1 is put at half-a-crown above mixed Nos.

*Foreign Ore.*—There is next to nothing passing in imported ore, consumers still having heavy stocks, and large supplies to come in against old contracts. Best rubio is put at 27*s.* c.i.f.

*Coke.*—Foundry and furnace coke tend downward, but gas house product is rather firm. Beehive is nominal at 37*s.* 6*d.*, and patent iron is quoted 30*s.* Local consumers of blast-furnace coke are very disinclined to pay 30*s.* for average Durham quality, delivered, which appears to be the lowest price asked.

*Manufactured Iron and Steel.*—In all branches of finished iron and steel orders are scarce, and some manufacturers are now very badly off for work. Whilst home quotations are upheld, export prices are falling, and in some cases orders can be placed for abroad at as much as 30*s.* below home rates. The following are among the principal home quotations:—Common iron bars, 14*l.*; steel billets (medium), 9*l.*; steel billets (hard), 9*l.* 10*s.*; steel boiler plates, 16*l.*; steel ship, bridge and tank plates, 10*l.* 10*s.*; steel angles, 10*l.*; steel joists, 10*l.* 10*s.*; heavy steel rails, 10*l.* 10*s.*; fishplates, 15*l.* 10*s.*; black sheets, 15*l.* 10*s.*; and corrugated galvanised sheets, 18*l.* 10*s.*

## NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

*The Coal Trade.*—The Joint Conciliation Board for the coal trade of South Wales yesterday had a very difficult question under consideration, and eventually appointed a committee to go into the matter. A clause is embodied in the national agreement under which a "maintenance allowance" may be made in cases where wages fall to extremely low levels. In view of the fact that the present rates are just 20 per cent. above the 1914 average earnings and the cost of living 103 per cent. above the pre-war level, the men have made an application for allowances for the lower-paid workmen. The workmen's representatives proposed a graduated allowance for every class of labour in receipt of a rate of wage of less than 7*s.* 8*d.* per day. For instance, where the standard wage was 5*s.*, it was proposed that the present percentage of 28·95 should be increased to 53·34, making a total wage of 7*s.* 8*d.*, and that the same principle should be applied to other rates which were below 6*s.* per day. The owners, while sympathising with the position of the men, declared that it would be impossible to make the allowances proposed without increasing the cost of production. This, it was contended, would only result in increased unemployment, for collieries already were working at a loss, and there was no hope of securing higher prices for coal. Ultimately it was agreed that a joint sub-committee should endeavour to agree to a scheme and report to a joint board meeting to be held on Tuesday. In view of this decision the delegate conference of the South Wales Miners' Federation convened for Saturday has been postponed for a week. The visit of Herr Hugh Stinnes, the German coal and iron magnate, to London, has caused quite a flutter in Welsh commercial circles, for it is believed that he is renewing pre-war activities in the coal exporting trade. In fact, there is evidence that the recent expansion that has taken place in speculative business with Italy and South America is in some measure due to the enterprise of Stinnes. At any rate, several cargoes of coal shipped to Genoa and the Plate have been traced to a London firm whose principles are in close touch with Stinnes, while a Cardiff ship-owning firm is also acting as agents for a company with a foreign title, and has lately despatched a number of cargoes to Italy. Meanwhile the general conditions, though somewhat brighter, show little change. While the foreign demand is good, as is verified by a more considerable inquiry for tonnage than has existed for some time past, the home inquiry continues restricted. All grades of large coal are in ample supply to meet buyers' requirements and prices are on the basis of 25*s.* 6*d.* for best Admiralty large, 25*s.* for second, and 22*s.* 6*d.* to 24*s.* for the leading Monmouthshires. Smalls, however, remain relatively scarce and alone command 19*s.* for bests and 17*s.* for ordinaries, but with a half to two-thirds proportion of large can be obtained at a discount of 1*s.* to 2*s.* Dry smalls, however, are in poor demand, and range from 12*s.* to 14*s.*

*Iron and Steel Trades.*—The Welsh tin-plate trade continues to show gradual improvement. There are now about 70 per cent. of the mills working, and inquiries are circulating on a more numerous scale. The order for 150,000 boxes of packing plates for British Columbia was secured by Messrs. Richard Thomas and Co., and the first shipment is to be made in December. Current prices are steady at 21*s.* to 22*s.* 6*d.*

## NOTES FROM THE NORTH.

GLASGOW, Wednesday.

*Scottish Steel Trade.*—The position of things in the steel trade of Scotland is far from satisfactory at present, and business during the past week has been extremely difficult to secure. Not only have the local producers been fighting against Continental material but English makers are now endeavouring to pick up any business on offer by quoting very keen terms, which are a bit under those which the Scottish makers are inclined to face. The temporary cancelling of the recently-placed Admiralty contracts has caused the outlook in this area to become blacker than it was, and instead of more plant being restarted, the arrangements for which had been made, there is a possibility of a decrease being made in the plant now in operation. One ray of hope exists in the fact that the Continental makers are so full up with orders that early deliveries cannot be promised, and as home prices have been considerably reduced recently the gap between these two sets of quotations is not now so great as it was, and the local works may secure some of the business presently in the market. Numerous inquiries are in circulation, but few have so far resulted in business, although several of them have a hopeful ring about them. The shipbuilding trade is at a very low ebb, and plates and angles are in poor request. Black sheets are in a very similar position, and few fresh contracts have been fixed up since the fall of 1*l.* per ton in the prices. Galvanised sheets are also rather off meantime, as Eastern buyers are only ordering very moderate lots. Export in general of all kinds of steel material is decidedly poor, and the outlook is not considered very bright. The following may be taken as the current prices, but are mostly subject to negotiation: Boiler plates, 15*l.* 10*s.* per ton; ship plates, 10*l.* 10*s.* per ton; sections, 10*l.* per ton; sheets, ¼ in., 12*l.* 15*s.* per ton, all net, delivered Glasgow. Galvanised sheets are called 18*l.* per ton, f.o.b. Glasgow.

*Malleable Iron Trade.*—Conditions in the West of Scotland malleable iron trade have not improved and the various works continue very slack. With a view to stimulating buying the associated bar iron makers decided to reduce prices as from Monday of this week by taking 30*s.* per ton off the price of "crown" bars and 10*s.* per ton off rivet, nut, bolt and spike iron, thus making the basis price for all 12*l.* 10*s.* per ton, delivered Glasgow. Whether these new quotations lead to much fresh business or not remains to be seen, but at any rate there are few establishments which could not do with considerable additions to their order books.

*Scottish Pig-Iron Trade.*—There has been little change in the state of the Scottish pig-iron trade over the week, and despite the small number of furnaces in operation there is still more iron available than is being taken up by consumers. The export side of the trade is also very quiet, but the easier tone of prices has brought out a better inquiry, although little business is going through. Hematite iron is also exceedingly dull because of the quietness in the steel trade. The current prices are as follow:—Foundry iron, No. 1, 6*l.* 12*s.* 6*d.* per ton; No. 3 6*l.* 7*s.* 6*d.* per ton, on trucks at makers' works; and hematite iron, 6*l.* 10*s.* per ton, delivered at the steel works.

*General Trade.*—In common with the depressed state of the iron and steel industries the majority of the engineering establishments are going very slowly and short-time is all too general. There are few good contracts on offer, and although there are prospects of several important orders, those responsible for the placing of these are holding off in the anticipation of securing more favourable terms by a little delay. Textile firms are not doing well at all, but there are one or two exceptions nevertheless. On the whole it is expected that the month of December will be rather quiet overall, but the general concensus of opinion is that with the turn of the year prospects all round will be better and that trade will gradually open out. Prices of almost everything are coming down, and with fuel and oncost charges considerably reduced the outlook is getting much brighter, but it is more than outlook that is wanted, it is actual business.

## NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, November 25, at 8 p.m., at Caxton Hall: Lecturette, "Electromagnetic Instruments—Problems in Design and Construction," by Mr. G. F. Shotter (Member); exhibits and demonstrations. Saturday, November 26, at 2.30 p.m.: Visit to the Locomotive Sheds of the Great Western Railway, at Old Oak Common. Friday, December 2, at 8 p.m., at Caxton Hall: Lecturette, "Notes on Maintenance of Electrical Accumulators," by Mr. B. L. Ladkin. Saturday, December 5, at 2.30 p.m.: Visit to Messrs. Duroglass Works at Blackhorse-lane, Walthamstow.

THE FARADAY SOCIETY.—Monday, November 28, at 8 p.m., at the Chemical Society, Burlington House, Piccadilly, W. 1. The following papers will be read and discussed: "The Effect of Cold Work on Commercial Cadmium," by Mr. J. Neill Greenwood; "Reaction between Cathodic Hydrogen and Nitrogen at High Pressures," by Messrs. J. N. Pring and E. O. Ransome; "The Electrolysis of Aqueous Solutions of Alkaline Nitrates with a Lead Anode, and an Electrometric Determination of the Constitution of the Complex Anion Formed," by Mr. F. H. Jeffery; "An Inhibition Period in the Separation of an Emulsion," by Mr. T. G. Nugent; "Induced Reactions and Negative Catalysis," by Messrs. N. R. Dhar and N. N. Mittra. A new adjustable thermostat for all temperatures between 0 deg. and 100 deg. C. will be exhibited by Dr. S. Judd Lewis and Miss F. M. Wood.

THE ROYAL SOCIETY OF ARTS.—Monday, November 28, at 8 p.m.: Cantor Lecture, "Processes of Engraving and Etching," by Mr. Arthur M. Hind, O.B.E., M.A., Slade Professor of Fine Art in the University of Oxford. (Lecture I.) Wednesday, November 30, at 4.30 p.m.: Ordinary Meeting, "The Preservation of Stone," by Mr. Noel Heaton, B.Sc. Sir Frank Baines, C.B.E., M.V.O., Director of Works, H.M. Office of Works and Public Buildings, will preside.

THE BRADFORD ENGINEERING SOCIETY.—Monday, November 28, at 7.30 p.m., Lecture in the Hall of the Bradford Technical College. Mr. A. A. Liardet, on "Wireless Telegraphy," with special demonstrations and reception of telephony and telegraphy from the principal European stations.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 29, at 6 p.m. Paper to be further discussed, "The Indian Railway Gauge Problem," by Mr. Frederick George Royal-Dawson, M.Inst.C.E.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, November 30, at 8 p.m., at the Royal Institution, Colquitt-street, Liverpool. "Modern Conceptions of Corrosion," by Mr. William Ramsay, F.I.C., M.Inst.Met.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, December 1, at 6 p.m. "The Cyc-Arc Process of Automatic Electric Welding," by Messrs. L. J. Steele and H. Martin.

THE ROYAL AERONAUTICAL SOCIETY.—Thursday, December 1, at 5.30 p.m., at the Royal Society of Arts, John-street, Adelphi. Major C. H. Scott will read a paper on "The Present State of Airship Development."

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (MANCHESTER CENTRE).—Friday, December 2, at 7 p.m., at the School of Technology. Paper on "The Locomotive from a Footplate Point of View," by Mr. J. P. Grassick, Member of the Glasgow Centre.

THE SHEFFIELD ASSOCIATION OF METALLURGISTS AND METALLURGICAL CHEMISTS.—The annual dinner will be held at the Royal Victoria Hotel, on Friday, December 2, at 7.30 p.m.

UNIVERSITY OF BRISTOL.—It has been decided to conform to the practice of most other English universities by granting a diploma (in lieu of a certificate) in engineering to students who, though not qualified for matriculation, pass the entrance examination for admission to the Faculty of Engineering and complete satisfactorily the course of study prescribed for this purpose.

THE FARADAY SOCIETY.—The annual general meeting of the Faraday Society will be held on December 13, at 7.45 p.m., in the Rooms of the Chemical Society, Burlington House, W. 1, when the Report of the Council will be presented and the election of officers and council will be announced. The meeting will be followed at 8.15 p.m. by an address by Professor A. O. Rankine, O.B.E., D.Sc., on "The Structure of Some Gaseous Molecules." This will be followed by a general discussion.

PERSONAL.—Mr. Noel Greenway, B.Sc.(Eng.), who was formerly with Messrs. Cammell Laird and Co., Limited, Birkenhead, the Wallsend Slipway and Engineering Company, Limited, and the Metropolitan Wagon Company, has started as a consulting mechanical engineer at Victoria Chambers, 5a, Temple-row, Birmingham.—The Anti-Attrition Metal Company, Limited, Glengall Works, Glengall-road, London, S.E.15, state that they have closed their offices, Cornwall Buildings, Queen Victoria-street, E.C., but opened more extensive ones at 1, Victoria-street, Westminster, S.W. 1.—Messrs. W. H. Allen, Sons and Co., Limited, Bedford, have secured from Messrs. Harland and Wolff a licence for the manufacture of Diesel engines under Messrs. Burmeister and Wain's patents.

# THE BELLUZZO STEAM-TURBINE LOCOMOTIVE.

CONSTRUCTED BY THE SOCIETA ANONIMA OFFICINE MECCANICHE, ENGINEERS, MILAN.

(*For Description see Page* 728.)

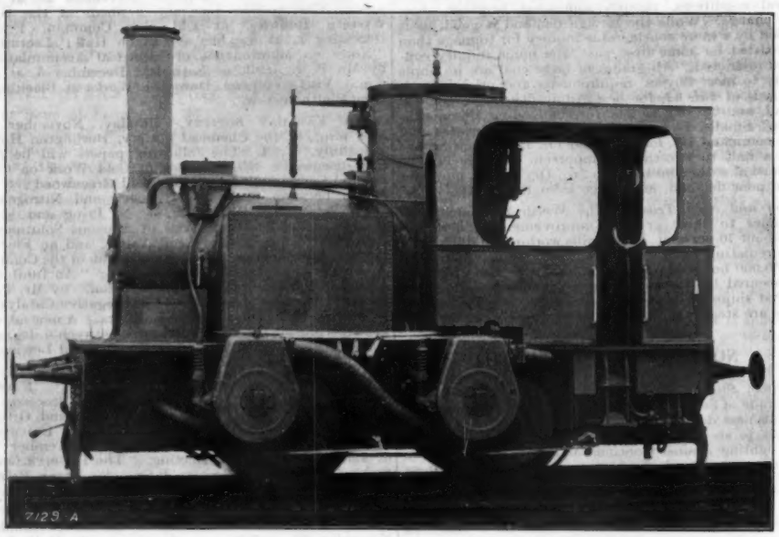



FIG. 1.

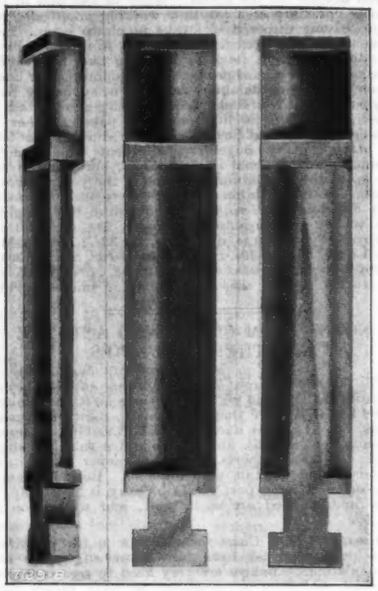


FIG. 4.

*Fig. 2.*

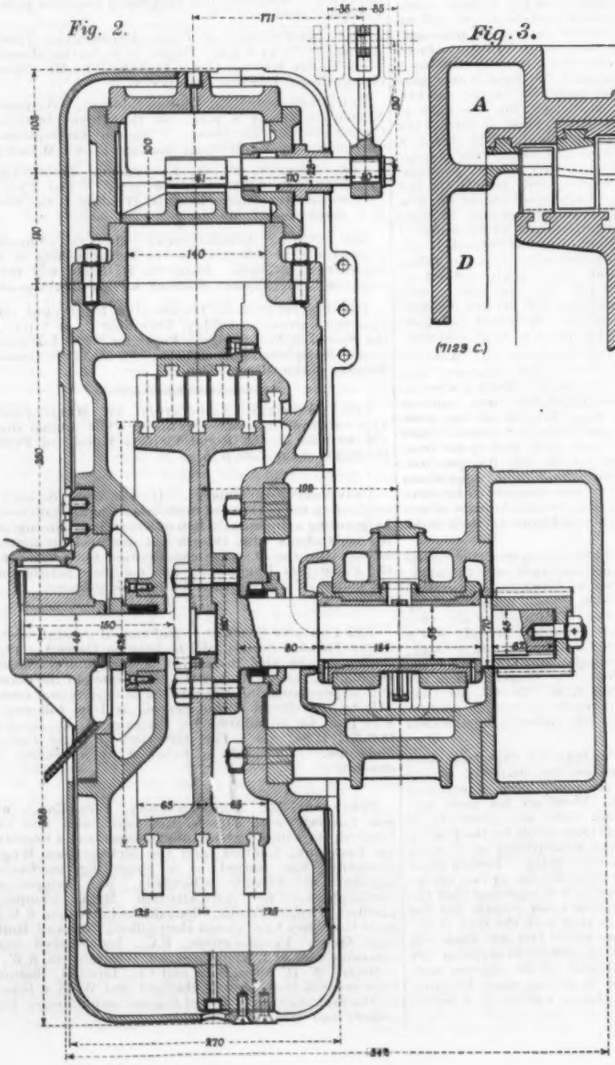
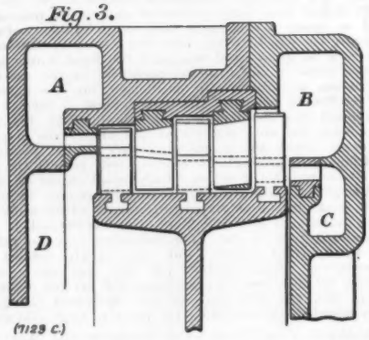



*Fig. 3.*




IMPERIAL WIRELESS.—With regard to the proposals for the Imperial wireless chain, the Postmaster-General has stated that the scheme was approved by the Government and was endorsed by a Committee of the Imperial Conference over which Mr. Churchill presided, and by the Conference itself in the following resolution: "It is agreed that His Majesty's Government should take steps for the erection of the remaining stations for which they are responsible, as soon as the stations are designed; that the Governments of Australia, the Union of South Africa and India, should take similar action so far as necessary, and that the Governments of Canada and New Zealand should also co-operate." The above scheme was accepted by the Prime Minister of the Commonwealth subject to giving full freedom of action to Australia to decide the method in which Australia will co-operate. No change in the policy of the Government has since taken place. The first two stations in the Imperial chain, Leafield and Cairo, will be completed and working by the end of this year, and a Commission of experts has been engaged in designing the remaining stations. Their report is expected within a few weeks, and on its receipt the construction of the stations will be proceeded with as quickly as possible.

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CHADWICK LECTURE ON "PROBLEMS OF NOISE AND FATIGUE."—A Chadwick public lecture was delivered by Professor Spooner (member of the International Committee on Industrial Fatigue) at the Public Hall, Blackburn, on November 21, on the subject of Noise and Fatigue. The lecturer stated that a period spent in the midst of working machines and mechanical operations causing deafening and strident sounds of a wide range, with shocks to the auditory nerves, produced a feeling of sensory fatigue; and that although that fatigue attacked primarily a single organ, it little by little extended to the whole nervous system, leading in some cases to such a feeling of weariness that it might impair the capacity for work in a greater degree than severe muscular fatigue. For some trades the noise was so great and continuous that before the workers reach the age of 40 they became more or less deaf; boiler makers, riveters, and trunk makers in particular, suffered in this way, whilst few people had normal hearing if they had lived in a great city for many years. The lecturer then proceeded to classify the primary kinds of noise calling for attention, particularly to our factories, and discussed the expedients which had been, and could be, employed to reduce, eliminate or prevent such noises. He explained the use of vibrometers for the detection of vibrations in high-speed machinery, and dwelt on the great value of rubber in solving many noise problems, particularly for flooring, the treads of stairs, and for roads (the construction of which had not kept pace with the development of vehicular traffic) in cases that would justify its use. The law relating to noise as a nuisance, both private and public, was touched on. There should be, the lecturer said, a standard limit of permissible noise, which, if exceeded, would be a legal offence.

# 300 H.P. TWO-CYCLE DIESEL ENGINE.

CONSTRUCTED BY ANSALDO-SAN GIORGIO, ENGINEERS, TURIN AND SPEZZIA.

(*For Description, see Page* 721.)

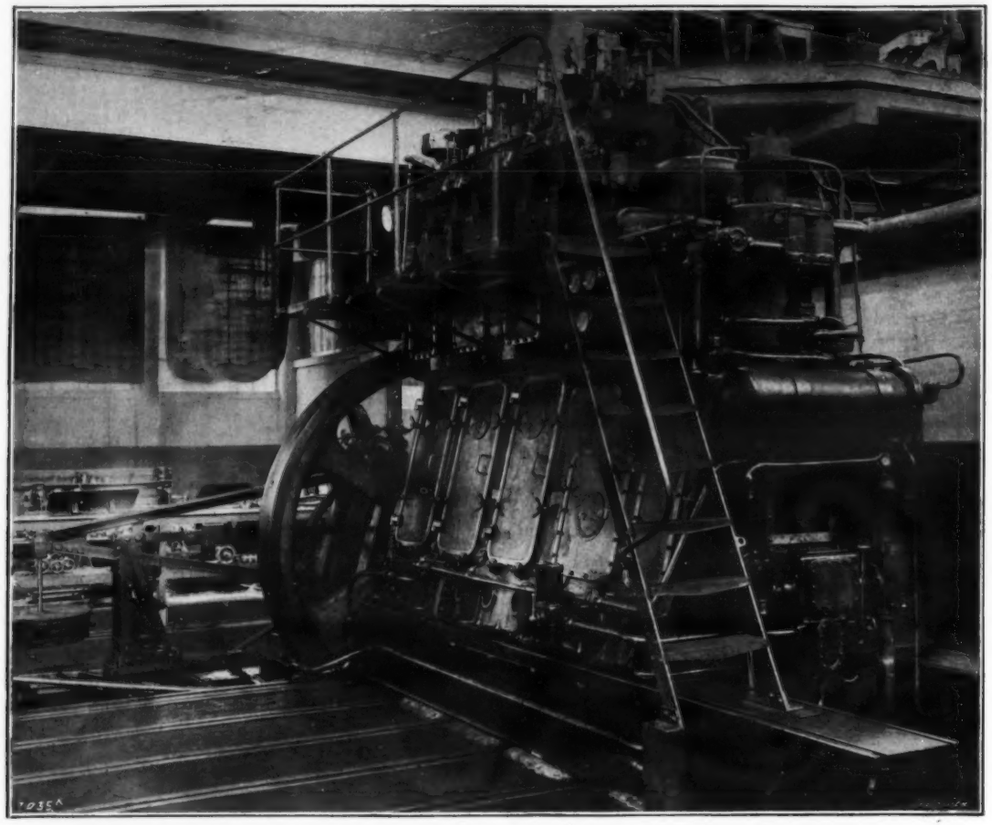


FIG. 1. FRONT OF ENGINE SHOWING VALVE GEAR.

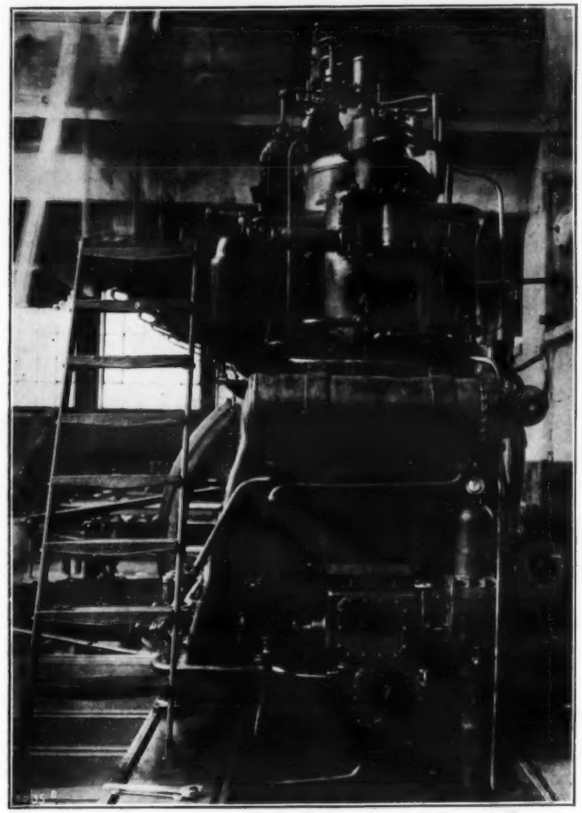


FIG. 2. AIR-COMPRESSOR END.

*Fig. 3.*

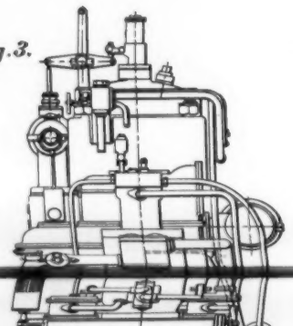


*Fig. 4.*

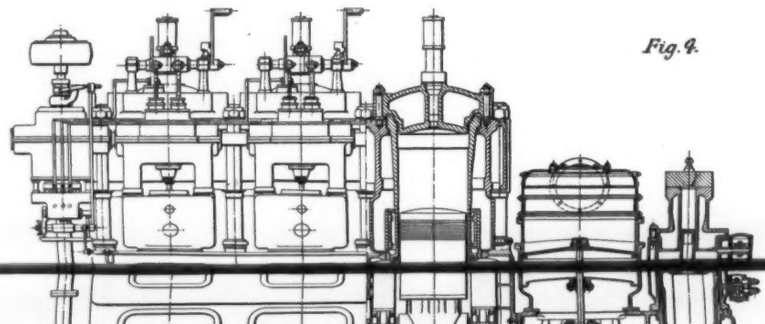
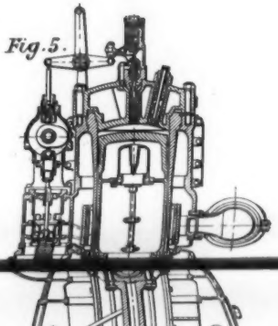
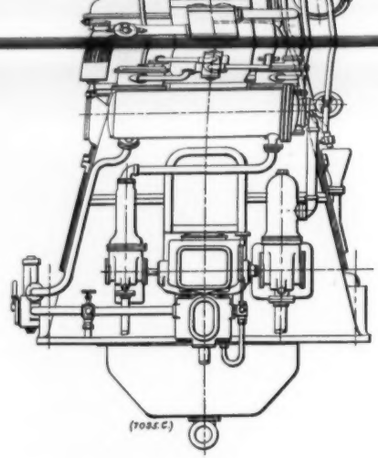
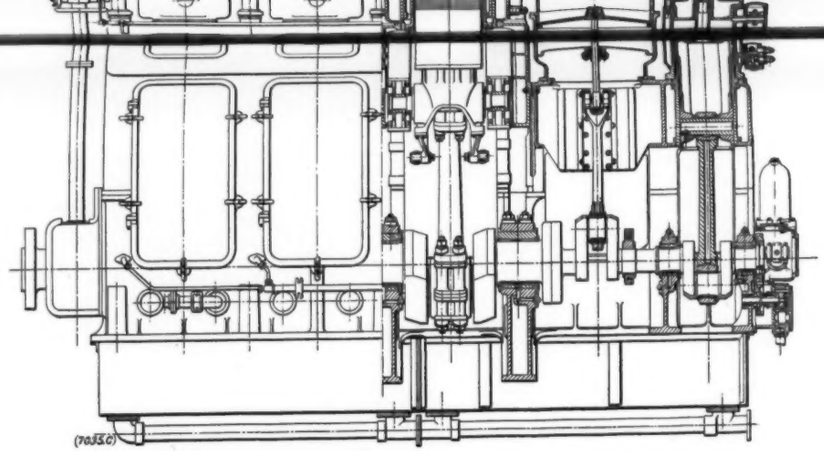


*Fig. 5.*







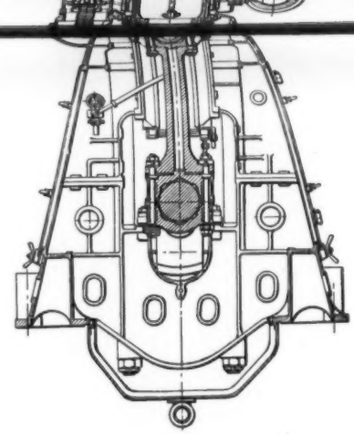


*Fig. 6.*

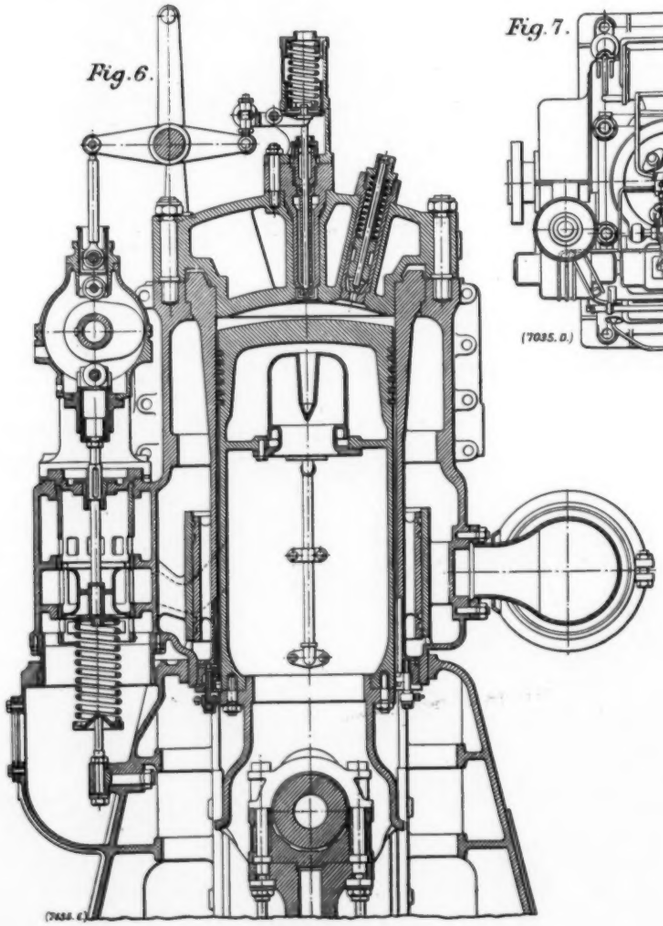


*Fig. 7.*

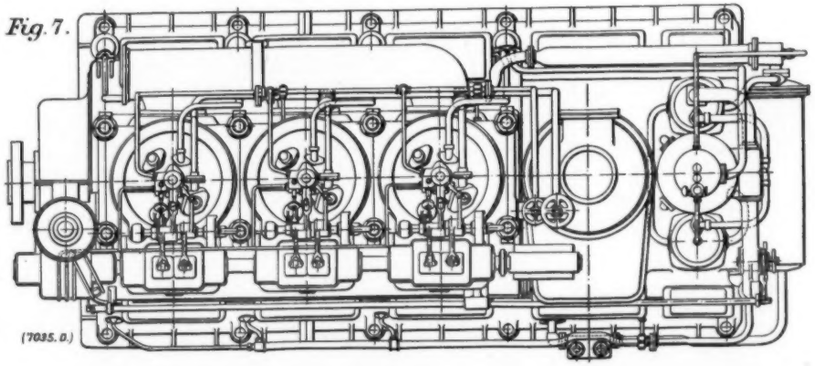
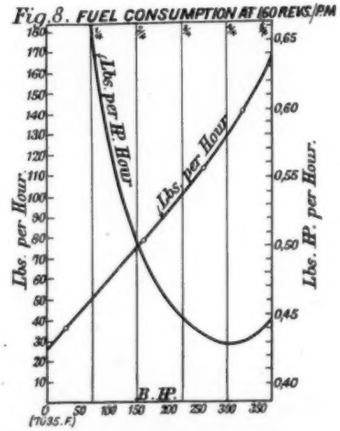


*Fig. 8.* FUEL CONSUMPTION AT 160 REVS./P.M.

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| | |
|---|---|
| Capacity ... ... ... ... ... | 300–400 h.p. |
| Diameter of cylinders ... ... ... | 390 mm. (15·35 in.) |
| Stroke ... ... ... ... ... | 550 mm. (21·62 in.) |
| Revolutions per minute ... ... ... | 160–200 |
| Scavenging air pressure ... ... ... | 2 lb. per sq. in. |
| Atomising air pressure ... ... ... | 720–1,125 lb. per sq. in. |
| Fuel consumption, ½ load ... ... | 0·491 lb. per h.p. hour. |
| Fuel consumption, full load ... ... | 0·430 lb. per h.p. hour. |

*Fig. 9.*

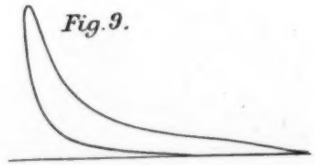
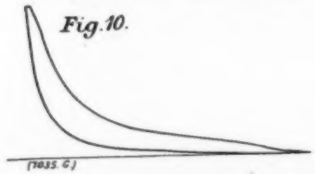


*Fig. 10.*



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|---|---|---|---|
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| For Canada— | | | |
| Thin paper copies | £2 | 18 | 6 |
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**Offices for Publication and Advertisements 35 and 33, Bedford Street, Strand, London, W.C.2.**

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3383 and 8598 GERRARD.


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*With a Two-Page Plate of a 300-H.P. TWO-CYCLE DIESEL ENGINE.*


## NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 729.


# ENGINEERING.

*FRIDAY, NOVEMBER* 25, 1921.


## ECONOMIC READJUSTMENT AND TRADE UNION PSYCHOLOGY.

FORTUNATELY it is being recognised more and more every day that even a moderate measure of industrial activity can only be achieved by a considerable reduction in the cost of production. This is apart altogether from the obstacles due to rates of exchange, international credits and the capacity of foreign companies and individuals to buy under terms of finance acceptable to sellers. This recognition of the basal principal of trade recovery is largely consequent on reflection stimulated by unemployment, and it is at least doubtful if this frame of mind on the part of a few of the leaders will long survive any improvement in work. Drastic measures have yet to be enforced over a long period of time to ensure cheaper output and to stabilise economic conditions. The part played by the employer in improved machinery and organisation cannot be expressed clearly and with precision, and it is too often unrecognised. Moreover, the practice of "ca' canny" nullifies it. Reduction in wage, which is at once obvious, is brought into high relief and may seem a one-sided provision, and thus we fear that further movement in this direction, which is inevitable will bring trouble. It is therefore pertinent to consider every possible phase of the subject which may encourage greater recognition of the true economic condition of the country, and this must in itself involve a freer play of individual judgment on the great mass of the workers.

Trade union organisations are in theory democratic institutions. The terms and conditions which begin or terminate a strike are supposed usually to be submitted to the individual workers, and action taken on their considered instruction. The so-called leaders are not in fact leaders, but channels through which the popular voice is conveyed. It would not be true to say, however, that leaders do not exist. They are found in trade union branches and in district councils, and it is they who call the tune to which others dance. It is important to discover, therefore, to what extent these actual leaders represent the general feeling of the workers, or how far they manipulate a situation and direct developments towards the expression of their own point of view.

On the imminence, or during the progress, of a dispute, the opinion is constantly expressed with a good deal of truth that the workers in an individual factory, or in a particular district, are not in favour of a stoppage and will have nothing to do with strike action, and yet it is found with monotonous regularity that proposals which do not appear to have the support of the individual are nevertheless given effect to, and disastrous disputes develop. How is it done? An examination of the procedure may throw some light on the matter. When an important issue arises between the employers and the workpeople, the matter is discussed between the former and the Executive Councils of the latter. The Executive Councils, generally speaking, are composed of men who have been sufficiently long in a position of responsibility to develop a faculty for looking at both sides of a question. If they were, in fact, real leaders with sufficient courage and authority to give effect to their own opinions it is doubtful whether the record of industrial disputes would have been so calamitous as has been experienced. But it is usually found that they do not feel sufficiently sure of their ground to act on their own initiative, and the matter is referred to a delegate meeting. The delegate meetings are constituted by individuals drawn from the various centres, sent with a mandate from their respective branches. The majority of district delegates belong to the younger school of trades unionist—keen, earnest, imbued with the idea that the organisation of society is wrong and that they know the remedy; but the majority do not possess that temperate mind and balanced judgment, which are necessary in those controlling gigantic forces. And what can be said of the mandate? It is well known that only a small proportion of trade unionists attend the meetings of their lodges. The work is in the hands of the zealots, who formulate policy on the basis of their own political conceptions, and it is from these individuals that the rank and file take their lead.

The most pronounced industrial danger the country has to fear is the extraordinary mental apathy of the average worker. It is safe to say that in the great majority of instances there is no independent thinking whatever, and that even where individuals have arrived at conclusions in conflict with that of the caucus, there are very few who have the inclination and the moral courage to represent their view, in face of opposition, usually more forcible than polite.

Moreover, the nature of ballots and the manner in which they are taken offer a striking commentary on their value as intelligent expressions of opinion. On a matter of vital importance to industry, only one-third of the workers affected may be found to vote. The branch meetings at which the ballot is taken are held more often than not at a public-house, the headquarters of the local section, and in an atmosphere with which the better type of workman prefers not to be associated. The looseness with which ballot papers are issued, and the scrutiny which is sometimes exercised over members in filling them up, throw grave suspicion on the value of their verdict.

What then can be done to produce a more healthy state of affairs. Clearly it is desirable to give the worker a true conception of the facts and to stimulate his interest to the point of action. If the employers believe that the sources of the workers' information are sometimes open to suspicion, or at the best, represent a purely partisan view, then it is surely evident that the employer himself must take a hand in propagating the truths which he is anxious that the worker should appreciate. The country has recently been experiencing a slump in trade, the reality of which would not be denied by any reasonable person interested in the situation, and yet the opinion has been sedulously manufactured and promulgated amongst the workers that the acute depression experienced has been the result of a deliberate conspiracy amongst the employers to create a situation which would enable them to deflate wages and improve their own position. It is found, too, that in the individual factory the most innocent or inevitable act is frequently regarded with grave suspicion, and motives are attributed, which have not the slightest foundation in fact.

It appears, therefore, that the necessity is more real than ever that the employer should take the worker into his confidence. The result would be two-fold, in that the worker would be put in possession of information which it is desirable he should know, and incidentally that by a more frequent meetings and interchange of views, a better feeling would inevitably result. In the large works or factory it is sometimes not possible for the principals to get into touch with their individual workpeople, but in such cases the works' journal, run on sympathetic and not entirely one-sided lines, is found an excellent medium. In the majority of instances, however, it is perfectly possible for the heads of a firm to meet their workpeople, either in section or as a body, and if such opportunities were occasionally taken, the result in dissipating the atmosphere of distrust and resentment so prevalent to-day, would be remarkable.

A substantial proportion of the British workers have a real measure of loyalty to, and pride in, the works in which they are employed, and a single heart-to-heart talk between themselves and their principals will do more real good than weeks of written propaganda, which they are taught to distrust and disregard. The air at present is full of menace. The workers are being taught that employers are taking the opportunity to kick them when they are down, and a resentment is being

nourished which is certain to find expression in the future. The fact is, of course, that employers are in the grip of international forces which it has been impossible for them to control, and if only as a premium on the assurance of future peace, they would be very wise to make it their personal business to see that the truth is made known.

In certain directions the fighting spirit has exhausted itself for the time being. Let not the one side nourish resentment at defeat, or the other cling to the idea that it has attained permanent victory. These crises will recur, and our economic structure is not strong enough to withstand the continual stresses of industrial war. The real leaders of industry, men with big minds and wide outlook, do not forget that part of their function is to lay the foundations of the future. In this regard they might profitably consider the means by which there could be developed a temperate labour opinion, and how far the cultivation of the personal factor can be made effective to this end.

## THE CLAUDE SYNTHETIC AMMONIA PROCESS.

The general principles involved in the production of ammonia by the Claude synthetic process have already been outlined in our columns,* and those of our readers who are familiar with them will realise that the subject is a particularly suitable one for consideration by chemical and mechanical engineers. The Chemical Engineering Group of the Society of Chemical Industry and the Institution of Mechanical Engineers are therefore to be congratulated on bringing the matter before their members at a joint meeting held on Tuesday last in the hall of the Institution of Electrical Engineers. On this occasion, a paper very comprehensively describing the Claude process and plant was read by Mr. J. H. West, who has had considerable experience of the working of the process in France. The discussion which followed the reading of the paper was not, however, of a very useful character, mainly owing to the fact that a number of members who wished to take part in it were precluded from doing so owing to lack of time.

It will be remembered that in the Claude ammonia process the direct combination of hydrogen and nitrogen is effected under pressure in the presence of a catalyst, and that the essential difference between this process and the Haber process is that, in the latter, a pressure of 200 atmospheres is employed as compared with 900 atmospheres used by Claude. At first sight this feature would appear to be a distinct drawback, but Mr. West was able to show very clearly that the exact opposite is actually the case. For instance, at any given temperature, the proportion of hydrogen and nitrogen remaining combined under conditions of equilibrium increases rapidly with increase of pressure, the proportion amounting to about 42 per cent. at 900 atmospheres and 607 deg. C., as against about 13 per cent. at 200 atmospheres and the same temperature. The quantities combining are also greater at lower temperatures, but the time required for the reaction becomes more than is commercially feasible if the temperature is reduced below about 600 deg. C., which is the temperature employed in the Claude process. Another important advantage of the high pressure is that very small pipes are required, those in the Claude plant having an internal diameter of only 8 mm. There is no difficulty with the joints of such pipes, and the necessary valves are quite simple and inexpensive.

The gases, mixed in the correct proportions, are first compressed to 100 atmospheres in an ordinary four-stage compressor, the design of which calls for no particular comment, and after passing through a separator in which any condensed moisture and oil are removed, are passed into a super-compressor which raises their pressure to 900 atmospheres. Mr. West gave some interesting particulars of this machine, the most remarkable feature of which is its extreme simplicity; in many respects its design resembles that of a vertical hydraulic pump. It is of the two-stage type, the gases, after being compressed to 300 atmospheres in the first stage, passing through an intercooler to the second stage in which the compression is completed. The plungers are of the parallel-ram type, the diameter of the first-stage cylinder being 70 mm. and that of the second-stage cylinder 40 mm. Both plungers have a stroke of 30 cm., and the machine, which is capable of dealing with sufficient gas to make 5 tons of liquid ammonia in 24 hours, runs at 150 r.p.m. The cylinders are water-jacketed and the plungers, which are hollow, are also water-cooled. Cooling water for the plungers is admitted through two pipes connected to the crosshead and passing through stuffing boxes in the bottom of the cylinder water jacket. The plungers are each packed by a single hydraulic hat leather which has proved quite effective and has given no trouble on a machine which has been running continuously for nine months in France.

It will be convenient now to deal with another important practical advantage which results from the high pressure used in the Claude process. The formation of ammonia by the combination of hydrogen and nitrogen is an exothermic reaction in which 717·6 calories are liberated per kilogramme of ammonia produced. When the proportion of combination is low, as is the case at 200 atmospheres, the heat produced is not sufficient to maintain the catalyst vessel at the proper temperature unless elaborate precautions are taken to reduce radiation losses to a minimum. In the Haber process, very large catalyst vessels must be employed for this reason, and the preliminary heating of these vessels is effected by injecting air and burning some of the hydrogen inside them. At 900 atmospheres, on the other hand, the heat produced is sufficient to make the reaction autothermic, so that small catalyst vessels can be employed and these vessels can be heated externally to start the reaction; in the Claude process this preliminary heating is effected electrically. The catalyst vessel required for a Haber unit capable of producing 20 tons of ammonia a day has an overall length of 42 ft. 8 in., an internal diameter of 2 ft. 7½ in., and a total weight of 74½ tons, while for a Claude plant of equal capacity 16 catalyst tubes, having an aggregate weight of only 11½ tons are required. The tubes weigh 14 cwt. each, are 7 ft. in length overall, and have an internal diameter of 4 in.; the advantage of the latter arrangement from the point of view of capital cost will be obvious. There are also many important advantages in connection with the operation of the plant, but the demands upon our space prevent us from referring to all of these. We may state, however, that three days is the time required to heat up the Haber plant after a stoppage, whereas the Claude plant will produce ammonia in from four hours to five hours after starting all cold.

As to the actual construction of Claude's catalyst tubes, Mr. West explained that a special nickel-chromium alloy was employed without any lining. Some of the tubes, he said, had been made of Messrs. Vickers' "Vicronic" metal, which has very remarkable heat-resisting properties. They are cast solid and bored out, and the head, or plug, is secured to the tube by an interrupted thread similar in principle to the breech mechanism of a gun. An inner tube of thin sheet iron, which contains the catalyst material, is attached to the head and this can be withdrawn and replaced by another tube of fresh material in 7 or 8 minutes. The ends of the Haber vessel, it may be mentioned, weigh 8 tons each, and each is secured by sixteen 3½-in. bolts.

The basis of the catalyst material employed in the Claude process is peroxidised iron, obtained by burning iron in oxygen, but certain other equally cheap materials, the nature of which Mr. West did not explain, are added to increase its activity and render it immune from "poisons." The iron oxide is, of course, reduced by the hydrogen in the catalyst tube. Carbon monoxide is one of the most serious catalyst poisons which is liable to be present in hydrogen obtained from water gas or coke-oven gas. This is eliminated in the Claude process, by passing the gas from the super-compressor through what is described as a "protector tube" before admitting it to the catalyst tubes. The protector tube is similar in design and construction to the catalyst tubes proper, but it is filled with spent catalyst material and heated to a temperature of about 400 deg. C. In this tube, any carbon monoxide present is converted into methane and water and any oxygen to water, both of which are separated out in the liquid form before the gas goes on to the catalyst tubes.

After this preliminary purification, the gas passes through heat interchangers, consisting of coils of piping immersed in water, to the catalyst tubes, the first two of which are arranged in parallel. On leaving these tubes, the ammonia produced is liquefied by merely cooling the gas to atmospheric temperature by passing it through a water-cooled coil. The liquid ammonia is collected in a separator, and the part of the gas which still remains uncombined passes in series through two other sets of heat interchangers, catalyst tubes, cooling coils and separators. The residual gases from the last separator contain only 2 per cent. or 3 per cent. of ammonia, which may be removed either by further cooling produced by the vaporisation of part of the ammonia or by absorption in sulphuric acid. After the removal of this ammonia, the residual gases are returned to the system. At intervals the ammonia collected in the separators is blown out by its own pressure into a collecting bottle, and finally it is transferred, by the same means, to a large storage cylinder for removal.

It is perhaps hardly necessary to point out that this simple method of collecting the ammonia in liquid form by merely cooling the gas to atmospheric temperature, is another important advantage of the high pressure used in the Claude process. In the Haber process it is necessary to inject water into the system for the recovery of the ammonia in the form of an aqueous solution, which has to be distilled if anhydrous ammonia is required.

With regard to the hydrogen and nitrogen used in the process, Mr. West explained that the latter could be made in standard liquid-air machines at a cost of only a few pence per 1,000 cub. ft., and added that, as only one volume is required to three of hydrogen, the cost of the nitrogen is an unimportant item. Cheap hydrogen, however, is essential for the commercial success of the process, and in this country, the cheapest source of hydrogen, he said, would be the gas from existing coke ovens. From the coke-oven gas, the hydrogen is separated by a process of fractional liquefaction, the gas, after stripping in an ordinary by-product plant, being compressed to 25 atmospheres and afterwards passed through a tower for the removal of carbon dioxide. Most of the carbon dioxide is absorbed by water, and the last traces are removed by lime water injected at the top of the tower. The gas is then progressively cooled, the ethylene and similar hydrocarbons liquefying first, and the methane, carbon monoxide and nitrogen subsequently in that order, finally leaving only the hydrogen in a gaseous state. The hydrogen, it may be mentioned, is allowed to expand in an engine doing external work, and being thereby cooled to about —210 deg. to —215 deg. C., is afterwards used in a heat exchanger to absorb the heat from the incoming coke-oven gas. The method used by M. Claude for lubricating the cylinder of this engine is interesting and ingenious. He effects this by admitting a small proportion of nitrogen with the hydrogen, and the former, being liquefied in the cylinder, provides the necessary lubrication. The cost of producing hydrogen in this way was given by Mr. West as 1*s.* 6*d.* per thousand cubic feet. In countries such as Norway, in which cheap water power is available, hydrogen can, however, be produced very cheaply by the electrolytic process.

In conclusion, we may quote from the paper some interesting figures as to the cost of power required for producing a ton of ammonia from coke-oven gas and from electrolytic hydrogen, respectively. In both processes, 279 kw.-hours are required for the production of the necessary nitrogen, 1,530 kw.-hours for the compression of the gases, and 175 kw.-hours are allowed for miscellaneous power requirements. The production of the hydrogen from coke-oven gas, however, requires only 1,287 kw.-hours as compared with 13,590 kw.-hours for the electrolytic process. The total power require-

* See Engineering, vol. cviii, p. 185; vol. cix, p. 223; and vol. cxl, p. 617.

ments for the two processes are thus 3,271 kw.-hours and 15,574 kw.-hours respectively. Taking the cost of energy produced by steam at 0·5*d.* per kilowatt-hour, the power cost for the production of a ton of ammonia with hydrogen obtained from coke-oven gas would be 6*l.* 16*s.* 3*d.*, and the corresponding figure using hydro-electric power at a cost of 0·04*d.* per kilowatt-hour with electrolytic hydrogen, would be 2*l* 11*s.* 11*d.*

We understand that Cumberland Coal, Power and Chemicals Ltd., with which company Mr. West is connected, have acquired three collieries in Cumberland with coke-oven plants capable of gasifying 1,000 tons of coal per week. These will be used to supply gas to a Claude plant to be put down in the neighbourhood. They have also acquired a controlling interest in the Tysse hydro-electric power plant in Norway, which supplies 100,000 electrical horse power to the works of the United Alby Carbide Company at Odda. The Odda works have also been acquired, and it is intended to erect there a Claude plant for the production of 156,000 metric tons of sulphate of ammonia per annum from electrolytic hydrogen.

## PLANTATION RUBBER AND ITS STANDARDISATION.

At the time of the London Rubber Exhibition of 1911 and, indeed, till the outbreak of the war, the synthesis of rubber was an eagerly discussed problem. At present the possibilities of synthetic rubber do not interest—except theoretically—anybody outside the countries which are not, or are no longer, in a position to cultivate rubber trees. Judged by production statistics even wild rubber, *i.e.*, the rubber from the virgin forests mainly of Brazil, takes a secondary rank. Last year the rubber plantations of the East were credited with having supplied 89·5 per cent. of the world's rubber production, and the rubber grower, merchant and manufacturer are chiefly concerned about two other problems, the over-production of rubber and its low price, and the so-called variability of the material. One does not understand why plantation rubber should be more variable than wild rubber. That, however, seems to be the impression of the rubber manufacturer, between whom and the rubber grower there exist misunderstandings and a mutual feeling of lack of fairness. The manufacturer complains that he cannot rely upon being supplied with a uniform material such as he should have, in order that he may be able to guarantee his wares, whilst the grower objects that the manufacturer would not tell him exactly what he wanted and would not advise him when plantations were in their infancy. Further, he complains that the manufacturer is still more ready to grumble than definitely to specify his wishes. Both sides sometimes put the responsibility upon the broker, with whom most of them deal, and the indirect discussion of grievances does not tend to smooth matters.

When, on the 16 inst., Dr. Henry P. Stevens read his paper on "Plantation Rubber, Effect of Different Methods of Preparatiou on its Behaviour in the Factory," before the second London meeting of the Institution of Rubber Industry (the first meeting of this Institution was noticed in our issue of October 21) Mr. Brooking, president of the Institution, and others practically pleaded for standardisation. They want a product as definite and uniform as iron and steel. Dr. Stevens made the apposite reply that iron and steel are not definite invariable materials. The pig-iron varies with the ores, and the steel has to be refined; the grower cannot refine his rubber, and the manufacturer certainly does not at present wish him to do so. The reply might have gone further. No biological products is invariable and definite in the strict sense. Different trees and different plantations will no more yield the same latex and do so every season than different vines, even if only a few yards apart, will all yield the same wine every year. If we do not yet speak of something akin to vintage in rubber, it may merely be because knowledge and experience are yet too imperfect. We believe —we may be behind with our knowledge—that the real part played by the resins and proteins in rubber, to which they are only apparently inessential, is still obscure, and that synthetic rubber remains unsatisfactory for this reason, among others.

Nobody, however, referred to synthetic rubber at the meeting, nor to the further considerations, though some of the speeches had the elasticity of rubber. Dr. Stevens contented himself with showing that the standardisation of plantation rubber is possible to a limited extent only. In the first instance, definite rules could not be laid down for more than half the rubber. About a quarter of the plantation area is held by natives who would individually have to be supervised to secure uniform methods; the washed, creped and packed product reaching Europe *via* Singapore cannot be uniform. On the plantations under European control up to 30 per cent. of the rubber is obtained as scrap. Instead of collecting in the cup, some latex runs down the tree, sticking to the bark which is damp and acid; the film of latex left in the cup is washed out with water, and the cup washings, leaves, &c., go into the scrap; the scrap may, or may not, be a good material, but the term does not denote quality. The latex rubber, *i.e.*, the latex coagulated in the factory by acetic acid, might be standardised; but of that some wares only may contain 15 per cent. and less, and the quality does not much matter then.

For high-class goods best quality is, of course, indispensable, but the further difficulties of averaging and grading, &c., intervene; Dr. Stevens thought that machinery makers might well direct their attention to the design of a machine for averaging large quantities of rubber. Then come the delays between coagulating and machining. The rubber has to be dried; sheet rubber is placed in drying houses in which the fires are always kept up, crepe rubber is sun-dried and may take up as much moisture again during the night as it lost the previous day. Even drying houses are subject to the atmospheric conditions, and are overcrowded after rainy days, and there is more absorption of moisture during transport. One member strongly recommended a process of rubber drying by gases such as the exhaust from internal-combustion motors; why the rubber thus treated should never reabsorb moisture, is not clear. The moisture, if not otherwise also injurious affects the rate of curing, and in that connection Dr. Stevens mentioned that storage of rubber tended to level up the rate of curing, *i.e.*, hasten the vulcanisation of a slow-curing rubber and *vice versa*. He did not suggest, however, that rubber would generally improve by storage, and he declined to commit himself to any definite period of storage as advantageous. As regards organic accelerators of the vulcanisation there was decided diversity of opinion at the meeting, as there was indeed on many points. Dr. Stevens favours accelerators. He also considered the use of a very slight proportion (1 : 800) of sodium bisulphite as quite harmless. The bisulphite is added to the rubber to prevent the development of an inorganised ferment which darkens the rubber and subsequently turns it streaky; the bisulphite is a preventative, not a cure, and if the darkening has once set in, it cannot be cured even by concentrated solutions of bisulphite.

Reference was made also to some troubles due to unfair or injudicious practice. Not every sheet of rubber shows its origin, much business is done through brokers in mixed goods, and consignments are said sometimes to arrive in boxes in which they had not left the East. The Rubber Growers' Association is trying to normalise the industry and the trade, and the new Institution of Rubber Industry will help. The use of alum and other chemicals, applied as a substitute for acetic acid during the war, has now been put down by the Association, Dr. Stevens stated, and Sir Frank Swettenham, who presided at the meeting, himself a grower, made a good suggestion. Let the manufacturers—he said—send out competent men to consult with the rubber growers on the spot. Mr. Brooking promised on behalf of the Institution that the suggestion should receive due attention. One might have thought that such a suggestion should not only have been made long ago, but already been acted upon; in this respect the useful and legitimate intervention of the broker may be an impediment. The Rubber Growers' Association can recommend methods of procedure, but unfortunately cannot enforce them.

## NOTES.

### The Junior Institution of Engineers.

At the annual general meeting of the above Institution, which took place last Friday at Caxton Hall, the council were instructed to take the necessary steps to cancel the Articles of Association recently adopted, in so far as they defined the qualifications for membership. It will be remembered that the decision of the council, put before the members at an extraordinary general meeting in July last, was to limit full membership in future to "persons holding responsible positions in the engineering or its allied professions." We criticised this policy as entirely subversive of the junior character of the Institution and utterly contrary to its spirit and traditions. The unanimity with which our views were endorsed by numerous correspondents was reflected in the overwhelming vote of the members to rescind the objectionable rules. The definition adopted by the general meeting with regard to suitable candidates for full membership reads as follows: "Persons who in the opinion of the council have received a general education and technical training such as to fit them for technical, executive or administrative posts in the engineering or its allied professions." The definition concerning associate membership is identical with the above, except that the words "have received" are replaced by "are receiving." No person may continue as an associate member after he has reached his twenty-sixth year. There are also cadet-associate-members, and associates. A proposal to abolish the associate member class received no support at the meeting. Provided that so many grades of membership are necessary for the Institution, the definition of the requirement for full membership, quoted above, does not seem unsatisfactory, and we congratulate the Council upon a prompt reversal of the mistaken policy of limiting such membership to "persons holding responsible positions." We are also very pleased to note that the word "Junior" on the publications of the Institution has already been restored to an equality of size and prominence with the rest of the title, and that the words "founded in 1884 for the junior members of the profession" will again appear as a continual reminder of the true scope and status of the society. The Institution has done most valuable work along its own lines in the past, and we trust the policy upon which its success was founded will continue.

### Slippery Roads.

Since so many of the roads have been adapted as far as knowledge goes to motor traffic, complaints have been rife as to the slipperiness of the different types of surfaces for horse traffic. The subject was taken up some time ago by the Ministry of Transport, and in 1919 an expert committee consisting of Mr. A. Dryland (now county surveyor of Middlesex), Mr. C. F. Gettings (county surveyor of Worcestershire), and Mr. A. J. Lyddon (formerly county surveyor of the North Riding), was appointed to consider it. The committee was encouraged to conduct experiments, which unfortunately, as far as regards road surfaces, have proved abortive. On the other hand experiments with modified forms of shoeing suggest that some relief may be hoped for in that direction. As a result of their practical work, which included observations on test lengths of roads in Worcestershire and Yorkshire, the conclusion is arrived at that the impervious class of surface necessary for mechanically-propelled traffic cannot, on account of its closeness of texture, be dissociated from a liability to slipperiness. The classes of surfacing laid included a coating of combined bitumen and tar, special asphalt carpet surfacing, cement grouting, &c. The latter, it may be observed, completely disappeared under heavy traffic in 48 hours, and though details of the method of grouting are not given in the report of the tests issued last week, it is difficult to conceive of any system of cement grouting which could possibly be expected to stand under such conditions. As regards temporary dressing with sharp grit, granite chippings, &c., this is to some extent a palliative. It is, however, notoriously difficult to ensure its application at the right time; often as it happens it is most required early on a sudden frosty morning,

and the committee's suggestion of gritting overnight is not of course possible frequently for lack of warning. Although not very constructive the report will probably do good in pointing out that our present knowledge offers no solution to the problem, with accepted methods of surfacing. Either we must look for something radically different, or reform the horse.

### Commercial Research and Inter-Imperial Trade.

A very interesting scheme, which aims at drawing closer together the bonds which unite the various sections of the British Empire, and at rendering completely effective, to the benefit of all concerned, the British Empire Exhibition (1923), has recently been announced by the executive council of that exhibition. There are to be five or more Commercial Research Fellowships for competition among Chambers of Commerce in the United Kingdom, the value of each fellowship to be not less than 500*l*., and to include a first-class return ticket to the Dominion, Crown Colony, &c., to which the Fellow will proceed. The research is to bear on the following points:—(1) The best means of promoting inter-imperial trade in a selected staple industry; (2) the methods whereby the British Empire Exhibition can further the interests of this trade; (3) the potential resources in raw materials and others in the Dominion or Crown Colony visited, and the best means for exploiting these in the mutual interest of the Dominion and this country; (4) the means whereby these undeveloped resources may be adequately represented at the British Empire Exhibition and brought to the attention of the interested financial or industrial groups. The British Chambers of Commerce have been approached by the executive council of the exhibition, whose address is 16, Hobart-place, London, S.W. 1. The closing date for entry for the competition on the part of the Chambers is December 15; the result will be announced on or before Saturday, December 24, and the successful Chamber will then proceed to the election of the Fellow. The name of the latter and the proposed subjects for investigation should reach the Secretary, British Empire Exhibition, at the above address, not later than January 14, 1922. The selected Fellows will be required to proceed to their respective destinations before the end of March next. All schemes which are of a nature to promote a more complete intercourse than now obtains between the United Kingdom and the various territories forming the British Empire deserve to be heartily welcomed, and we trust the one referred to above will be readily responded to. If so, it should bear useful results several months before the date for the opening of the British Empire Exhibition (1923).

### Local Authorities and Electrical Fittings.

In a case heard and decided last week by Mr. Justice Russell, a point of considerable importance to local authorities who supply electricity under statutory powers was considered and determined. The facts were very simple. Certain ratepayers of Liverpool sought a declaration that the corporation of that city were not entitled to carry on the trade or business of providing, selling, supplying, erecting, installing, altering, and/or repairing electric light fittings, and wires and electric bell fittings and wires in houses and other buildings. A declaration was also sought that the corporation had no power to expend capital borrowed for their electrical undertakings, or rates, or any part of the city fund. The corporation defended the action on the ground that power to do the acts complained of had become vested in them by reason of the fact that they had vested in them all the rights and privileges of the Liverpool Electric Supply Company, Limited, and the Garston and District Electric Supply Company, Limited. The undertakings of these two companies had been transferred to them by two Acts passed in 1896 and 1902 respectively. The Act of 1896 authorised the purchase not only of the "statutory undertaking" but the whole of the undertaking and other works of the Liverpool company, with all their rights, powers and privileges, at the date of the completion of the purchase, subject to all contracts, obligations, rights and liabilities. Mr. Justice Russell held that the Liverpool Corporation had been authorised, by this Act passed in 1896, to step into the shoes of the Liverpool company and to carry on all their business. He consequently gave judgment for the defendants. With regard to the Garston Company's Act he was apparently of opinion that if the Liverpool Corporation had been compelled to rely on that alone they would have been in a difficulty; but he was satisfied that they were endued with sufficient power by the earlier Act of 1896. Before coming to this very important conclusion Mr. Justice Russell had to consider Section 23 of the Electric Lighting Act, 1919, which provides that "any local authority authorised by special Act or by Order to supply electricity may provide, let for hire, and in respect thereof may connect, repair, maintain and remove (but shall not, unless expressly authorised to do so by the special Act or Order, manufacture or sell) electric lines, fittings, apparatus and appliances for lighting, heating and motive power, and for all other purposes for which electricity can or may be used, and with respect thereto may demand and take such remuneration or rents and charges, and make such terms and conditions as may be agreed upon." It was contended that the proviso, in brackets, would prevent the Liverpool Corporation from "manufacturing or selling"; but the learned judge was satisfied that the transfer of powers effected by the Act of 1896 was sufficient to give them these powers. It is useful to note, however, that he only expressed his view on this part of the case after very great consideration.

### Coal-Mining Machinery.

The interesting feature of the Report on Mines and Quarries issued by the Mines Department, has reference to the extent to which electricity is now used in the coal mines, as there has been a gratifying increase in recent years, notably in Scotland, South Wales, and in the northern districts. The report is concerned with the year 1920, and the census of the machinery is taken on January 21 each year. On that date, in 1920, the total horse-power of electrical machinery underground was 618,868 h.p. in coal mines alone, as compared with 597,321 h.p. in the previous year. This is apart altogether from surface machinery, and it is rather surprising that the total of this latter is only 461,954 h.p. Thus the total for all purposes in the coal mines is just over 1,080,000, or an increase of 5 per cent. on the total of the previous year; the increase in 1919 over 1918 was 6·58 per cent. A very large part of the power underground is for haulage and pumping, the former accounting for 257,049 h.p., and the latter for 279,612 h.p. We have already indicated that Scotland leads the way in the adoption of electric power underground, and more than a quarter of the total, namely, 166,192 h.p., is in use in North Britain; South Wales comes second with 137,624 h.p. Progress in Scotland has been remarkably steady, because eight years ago the total power of electric motors, &c., was only 80,000 h.p., and the advance has been practically unchecked. This also was the total eight years ago in South Wales, so that here the progress has not been nearly so great. In what is known as the northern district of England, however, the advance has been fairly steady, from about 63,000 h.p. about eight years ago to 128,814 h.p. now. If we take the horse-power at present employed underground, the Scotch result is equally remarkable. It is true that in the last two years there has been an abnormal increase in the number of persons employed, and consequently the power per employee is rather less than it was in 1918. Then it was practically 1·5 per person in Scotland, whereas the best result in any district in England was only half this, namely, in the northern part of England, 0·75. The ratio for last year was just over 1·35 for Scotland and 0·65 for the northern parts of England. A gratifying feature is that there has been a very steady increase in the number of coal-cutting machines in use in the coal mines. In 1910 the number was only 2,000, whereas it considerably exceeded 5,000 in 1920. The increase in the use of percussive and rotary drills was from about 600 to nearly 2,000—while in bar, chain and disc machines the advance has been from 1,400 to nearly 3,200, the number of disc machines and of chain machines being about equal, namely, about 1,250 of each, whereas of bar machines the number has been about 700. There has been a corresponding increase in the amount of coal cut by machines, the increase in ten years being from over 16,000,000 tons to over 30,000,000 tons, or an increase of from 6 per cent. to nearly 13 per cent. of the total tonnage of coal mined. The work of electrical machines has increased at a greater ratio than that of compressed air machines, the advance in the case of the former being from about 9,000,000 tons to about 18,000,000 tons, and in the case of the latter from 7,000,000 tons to 12,000,000 tons. A further gratifying point is that in 1920 there were only 9 fatal accidents (definitely due to electricity) investigated by H.M. Inspectors of Mines. Six of the accidents took place on the surface and only three were in the mine, the accidents involved ten deaths. There has been a steady decrease in the number of persons killed by electric shock below ground, from 15 ten years ago to three last year.

## THE PUBLIC WORKS, ROADS AND TRANSPORT EXHIBITION.

A really very good display of concrete mixing and handling machinery, tar macadam plant, road rollers, tipping wagons, and other municipal and contractors' vehicles has been got together at the Public Works, Roads and Transport Exhibition, which opened at the Royal Agricultural Hall on the 17th inst. The branch of work which this exhibition represents is one of special importance at the present time in that it is closely connected with many of the activities which are concerned with relief works. It is only too well known that the paucity of orders which is common to most businesses at present is evidence of financial disorder, and has nothing to do with any absence of real need for work of all kinds. Most of the postponement and destruction of the war has still to be made up. This information is unfortunately of little use to the manufacturer, but it has a bearing on the subject of the exhibition with which we are now concerned.

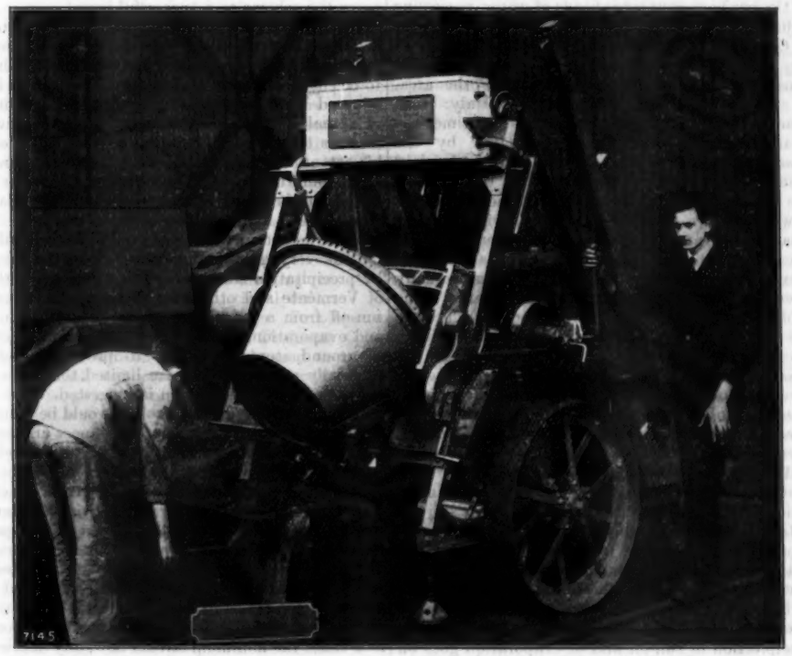
The roads and similar public works which are being undertaken as relief measures are mostly genuine pieces of work, and one may expect that many of them would have been entered on within a reasonable period, even had there been no trade slump. This is as it should be. Relief efforts are better devoted to the financial backing of genuine needs than to the carrying out of more or less unwanted projects. If, however, work is to be done at once as a relief measure, instead of being left until ordinary economic causes would result in it being put in hand, it should be undertaken with a full sense of responsibility, and in the most economic manner possible. If men are to be paid for doing something which it is a matter of indifference whether it is done or not, then it does not really much matter how they do it. If, however, a relief work is some important job put in hand now instead of later, when finance is less stringent, then it should be carried out with as much care for efficiency as if it were the subject of a keenly competitive tender. Any other procedure, instead of benefiting the unemployed, merely reduces the credit of the body undertaking the relief work, and lessens the possibility of it extending its activity in similar directions. It also loads up a public work with unnecessary and hampering capital charges.

The bearing of the Public Works, Road and Transport Exhibition on this matter is amply illustrated by a general inspection of the stands. Particularly in the direction of concrete machinery, tar macadam mixers and similar classes of road plant will a large amount of material be seen which might be employed much more extensively than it is on relief works. We need not repeat ourselves, but to cut out a machine and use ten men where one would do is to the benefit neither of the country, nor in the long run of the unemployed. It is plant of this kind and vehicles which form the basis of the exhibition. The latter form a very important and striking item, and we shall refer to some of the exhibits which comprise it more fully later, but the economic advantages of such machines have, perhaps, become more fully realised in this country than has that of the fixed or semi-portable plant which is now available for public works, either on a large scale or a small. One of the most obvious

pieces of plant of this class is the concrete mixer, and this is to be seen in a great variety of models at the exhibition. These range from small hand-operated machines of 2½ cub. ft. capacity to large power-driven machines up to 10 cub. ft. capacity or so. The smallest machine shown is, we think, that producing a 2½ cub. ft. batch, which is exhibited by Messrs. George Waller and Son, Limited, of Stroud, Gloucestershire. The machine is built either for hand or petrol engine driving.

Small machines are also shown by Millars' Timber and Trading Co., Limited, of Pinners Hall, London, E.C., and The Australia Concrete Machinery and Engineering Co., Limited, of 607, Salisbury House, London Wall, E.C. 2. Another small machine of a very simple type is shown by Mr. Frederick Parker, of Dun's Lane Engineering Works, Leicester. This is hand-driven, and consists of a drum revolving on ball bearings, and hand-wheel on a horizontal shaft for giving the rotary motion. A tipping lever serves for moving the drum into the position for emptying. This and other somewhat similar models are mounted on small wheels for transit. These very small and simple machines certainly have a field of usefulness, but for road-making and similar work a somewhat more complete or complicated machine will generally be used. An excellent example of such a machine is furnished by the Ransome "Runabout" lightweight mixer, which is illustrated in the accompanying figure. This machine is shown by The Ransome Machinery Co. (1920), Limited, of 14–16, Grosvenor Gardens, S.W. 1. The machine has a mixed batch capacity of 5 cub. ft. As will be seen, it is fitted with large road wheels to facilitate handling, while a pair of jacks incorporated with the discharge end of the frame, practically fix it in position, and give rigidity to it when in use. A travelling feeding skip on the front of the machine descends to ground level for charging from a barrow, and automatically tips into the drum when at the top of its stroke. The drum has one opening for loading and discharging, and tilts over outward for emptying. A 3 h.p. petrol or paraffin engine is fitted, and drives all motions. The lever controls are all conveniently placed, and easy to get at.

Other concrete mixers are shown by Messrs. Stothert and Pitt, Limited, of 11 Victoria-street, S.W., who exhibit various of their well-known "Victoria" machines. This firm also shows a combined stone dryer and mixer, this being a type of plant which is also shown by several other firms. As an example we may refer to the stone dryer and tar macadam mixer shown by Mr. Frederick Parker, of Leicester. This consists of a mixing barrel on the lines of a concrete mixer, with a charging hopper which travels to ground level for filling and is pulled to its upper position by steel ropes. It automatically discharges into the barrel. This latter is revolving, and acts as a dryer and mixer. After a batch of stone has been charged into the barrel it is dried and heated by the hot-air and gas discharge from a burner fed with petroleum under pressure. The arrangement is the well known one which has many applications, the oil being carried in a closed tank, and the pressure being provided by an intermittently operated hand-pump. A sliding door covers the mouth of the drum during the heating operation. When the stone is heated up, the discharge from the burner is shut off, and the tar is run in. The whole of the stone becomes coated with tar in about a minute, when the barrel tips over to the back of the machine and discharges. The tar boiler is carried above the heating burner. All motions are driven from an oil engine mounted on the main framework.



PORTABLE CONCRETE MIXER; THE RANSOME MACHINERY COMPANY, LIMITED, LONDON.

The majority of the stone dryers on view are of the long revolving horizontal cylinder type, as exemplified in the well-known dryers made by Messrs. Electro-Metals, Limited, of 56, Kingsway, W.C. 2. This firm show a working model of one of their plants. It is not, of course, suggested that all these horizontal cylinder plants are similar. Each firm has its own arrangements and patents, but many have in common the use of the long horizontal cylinder as against the drum type of arrangement described above. The question is to a large extent a matter of continuous treatment against batch treatment. Other machines of the horizontal cylinder type are shown by Messrs. Builders' and Contractors' Plant, Limited, of 15, Victoria-street, S.W. 1, Messrs. Millars' Timber and Trading Co., Limited, of Pinners Hall, London, E.C., and Messrs. Goodwin, Barsby and Co., of Leicester. The "Amman" plant, which is shown by Messrs. Builders and Contractors' Plant, includes a tar macadam mixer at the end of the dryer. The whole arrangement makes a very long machine. It is built in three sizes, and we are not sure which of the three is exhibited, but we note that the largest is 29 ft. long. This seems a somewhat unwieldy vehicle, for street travel, but we were assured that the example on show had come through the city on its own wheels.

Stone breakers may naturally be mentioned in connection with the macadam work, and most of the well known builds of this class of machine are to be seen at the exhibition. Examples are shown by Messrs. Hadfields, Limited, of Hecla Works, Sheffield; Messrs. H. R. Marsden, Limited, of Soho Foundry, Meadow-road, Leeds; and The Patent Lightning Crusher Co., Limited, of 14a, Rosebery-avenue, E.C.

Mention of stone breakers leads on somewhat naturally to dealing with pulverisers shown by The Gannow Pulverizer Co., Limited, of Empire Mill, Shed-street, Burnley. The special feature of these machines is a circumferential grid through which the pulverised material is discharged. The advantage of the circumferential arrangement is that any hard items, such as pieces of scrap iron, which may be in the material being dealt with, do not become wedged in the grid, and damage or break it, but are forced through by the action of the beaters. The machines are being employed for pulverising a large variety of materials, a very interesting application being the treatment of house refuse. This is directly treated in the machine, and has no tendency to clog even when wet.

No attempt is made to separate broken crockery or similar material before treatment, so that the procedure is a very cheap one. The refuse after pulverising appears as a black mould, which is in no way distasteful in appearance, and is said to harbour neither vermin nor flies. It has no tendency to burn in tips and has been utilised as a manure for heavy or newly turned-up land.

The only other machine with which we have space to deal is an interesting tamping machine shown at the stand of Messrs. G. Percy Trentham, Limited, of Winchester House, Victoria-square, Birmingham. The London address of the firm is 7, Queen-street, Cheapside, E.C. 4. Messrs. Trentham are interested in this machine as contractors, and have utilised it in their own business. It is manufactured by Messrs. B. Johnson and Son, of Wharfdene, Skipton-road, Ilkley. The tamper is a self-contained travelling machine with road wheels. A 2½ h.p. petrol engine is mounted on the framework and serves to operate the tamping ram. This has a weight of 75 lb. and makes 60 blows a minute. The drop is 24 in. The ram is lifted by a friction wheel, which at each revolution grips the ram during part of its stroke and lifts it. It then frees the ram, which falls with its own weight. The ram can be adjusted to tamp either on the level or at the bottom of a trench, and can be traversed sideways to cover a surface. Traverse is by hand lever.

We must now refer to some of the vehicle exhibits which form such a striking and important feature of the show. Practically every well-known maker of vehicles, which come within the definition of public works or municipal and contractors' service, has an exhibit, or exhibits, having definite reference to the objects of the exhibition. There is no padding out with the ordinary petrol lorry. It is not possible in the space at our disposal to mention all the firms which fall within the classes with which we are now concerned, but it is also not necessary, since both the firms and their products are well known to our readers and many of the vehicles shown have been illustrated at one time or another in our columns. If one takes only some special class such as road rollers, it is found that about 14 different machines are exhibited, there being, we think, no duplicates. Many of these machines are naturally of standard types, and fine examples are to be seen of the steam rollers of Messrs. Marshall, Sons and Co., Limited, of Gainsborough; Messrs. Ruston and Hornsby, Limited, of Lincoln; Messrs. Wallis and Steevens, Limited, of Basingstoke; and Messrs. Aveling and Porter, Limited, of Rochester. In addition to these, which are mainly heavy machines, an interesting new 5-ton tandem steam-roller is shown by Messrs. Robey and Co., Limited, of Lincoln. Rollers are also shown by the Allied Machinery Company, Limited, of 132, Queen Victoria-street, E.C. 4, and Messrs. Millars' Timber and Trading Company, to whom we have already referred in other connections.

The greatest points of novelty in the particular feature with which we are now dealing is probably

contained in the oil engine-driven rollers, although one of the steam rollers we have referred to above is of a new and novel type, which we hope to describe in detail in a later issue. The number of petrol-driven road rollers is a remarkable indication of the success with which the paraffin and petrol engine is pushing itself in all varieties of work and, incidentally, is a commendation of the policy of Messrs. Barford and Perkins, Limited, of Peterborough, who have built this type of machine for many years. It is very clear, however, that this firm does not propose to stand by and let the field be occupied by other firms, and a remarkably interesting new machine is exhibited by them. This is a 10-ton or 12-ton three-wheel machine driven by a 40-h.p. engine built by Messrs. Peter Brotherhood, and of the type used in that firm's farm tractor. The roller has a three-speed gear-box giving rolling speeds, forward and reverse, of 1½ miles and 2¾ miles an hour, and a forward travelling speed of 4 miles an hour. The gearing is all enclosed. The weight of the roller can be varied by 2½ tons by water ballast in both front and back rolling wheels, so that the correct proportion of weight may be maintained. An interesting new 8-ton motor roller is also shown by Messrs. Ruston and Hornsby, Limited, of Lincoln. This is also a three-wheeled machine with enclosed gearing. Three speeds are provided both forward and reverse. To some of these interesting new machines we will hope to return later.

Turning to vehicles of other types we may refer to the very complete display of road sweepers, gulley cleaners and tipping wagons shown by the Lacre Motor Car Company, Limited, of 78, York-road, King's Cross, N. 1. This firm's new gravity tipping fitted to the wagons shown is of great interest. The arrangement is a hand-tipping one operated through pinions and racks, and the body control is such that the centre of gravity of the moving part travels along a horizontal line during the tipping operation. This obviously means considerable saving both in manual effort and wear and tear as compared with the more usual arrangements in which the centre of gravity rises. Messrs. Laffly (England) Company, of 14, Addison-avenue, W. 11, also show motor sweepers, dust refuse wagons, and a 7-ton petrol roller. Steam wagons are shown by such well-known firms as Messrs. Mann's Patent Steam Cart and Wagon Company, Limited, of Hunslet, Leeds; the Yorkshire Commercial Motor Company, of Vulcan Works, Hunslet, Leeds; Messrs. Clayton Wagons, Limited, of Leeds; Messrs. Richard Garrett and Sons, Limited, of Leiston; Messrs. Fodens, Limited, of Sandback; the Sentinel Wagon Works (1920), Limited, of 14 to 16, Grosvenor Gardens, S.W. 1; and Messrs. Atkinson and Co., of Frenchwood Works, Preston. Messrs. Atkinson's wagon has the distinction of being driven by a uniflow engine.

Several firms show interesting trailers, and we may mention the neat and workmanlike-looking steel-framed examples exhibited by Messrs. R. A. Dyson and Co., Limited, of 76 to 80, Grafton-street, Liverpool. Various sizes and builds are shown and in the latest model the swinging sideways of the draw-bar owing to the trailing vehicle going round a curve, causes both the front and rear wheels of the trailer to adjust themselves to the new path, the draw-bar and the fore and rear wheel carriages being connected by a linkage. All-steel trailers are also shown by Messrs. Carrosserie Latymer, Limited, of Pamber-street Works, Walmer-road, W. 10, and an either-side tipping trailer by Messrs. Tuke and Bell, Limited, of Lichfield. An all-steel trailer with a side and end-tipping body is exhibited by the Eagle Engineering Company, Limited, of Warwick. Other vehicle exhibits we may mention are examples of their steam tractors shown by Messrs. W. Tasker and Sons, Limited, of Andover, and Messrs. John Fowler and Co. (Leeds), Limited, of Leeds. Electric vehicles are shown by a number of firms such as Messrs. Electricars, Limited, of 47, Seymour-place, W. 1; Messrs. British Electric Vehicles, Limited, of Churchtown Works, Southport; and the General Vehicle Company, Limited, of 43, Shoe-lane, Holborn Circus, E.C. 4. An example of their petrol-electric chassis is shown by Messrs. Stevens Petrol Electric Vehicles, Limited, of 68, Victoria-street, S.W. 1, and of "Peerless" petrol lorries fitted with a new tipping gear by Messrs. Slough Lorries and Components, Limited, of Slough, Bucks.

## LITERATURE.

*Hydro-Electric Engineering.* Vol. I. *Civil and Mechanical.* Editor, A. H. Gibson, D.Sc., M.Inst.C.E., M.I.Mech.E. Contributors, H. D. Cook, M.Sc., B.E., and the Editor. London: Blackie and Son, Limited. [Price 25s. net.]

This book evidently forms the introduction to a very comprehensive work on the development of water power resources, a topic that is deservedly receiving very much attention, for in the near future hydro-electrical development will offer much scope for the display of energy and engineering skill. It is unfortunate and may prove calamitous, that in the British Isles, the opportunities for exploiting the resources of water power are very restricted. The generally level surface and the fairly uniform rainfall throughout the seasons are not favourable to the production of large heads of water, possessing abundant energy. The total horse-power available in Great Britain from this source is smaller than in any of the leading countries of Europe, whether considered absolutely, or relatively to the area, or to the number of population. Italy, with practically the same area, has about four times the available horse-power, and stimulated by the absence of steam-raising sources, that we have in abundance and have abused with recklessness, she has to her credit developed six times the horse-power that we have. Switzerland, with a much smaller area and population, but under the same compelling influence of a lack of fuel, has been very active in providing water-power, and has actually developed 125 h.p. per square mile of area. The table drawn up by the authors, and from which we are quoting, shows other statistics which were unexpected. For instance, the United States, possessing a share in the latent powers of Niagara, revelling in the potentialities of the magnificent waterway of the Mississippi, and controlling the mountain streams of the Far West, have a smaller horse-power per square mile than Great Britain, and have developed but a slightly greater percentage of the total available than has this country, which is regarded as rather negligent of this store of potential wealth. Germany, who has only a small supply per square mile, early perceived the value of this asset and has outstripped all other nations in development, having utilised more than one-half of her total. The drawback of a wasting asset is absent in the case of water power. The cycle of precipitation of run-off and of evaporation goes on unceasingly from year to year, and exhaustion has not to be feared.

The world's available resources of water power, known and estimated, amount to about 200,000,000 h.p., but a considerable percentage is not capable of commercial development. Only about one-tenth of this force is in actual operation, and there is therefore a large field open to enterprise. This estimate is exclusive of tidal power, a force of unknown and perhaps illimitable extent, that has attracted much attention lately, but of whose value to the industry of the future it is premature to conjecture. The authors touch on the subject, and their decision naturally carries such great weight, that one hesitates to express any distrust of their considered opinion. The authors may be justified in saying that "with a spring tidal range of 20 ft., and a range of one-half this amount at neaps, it is possible to generate, by approved methods of operation, an average daily output of approximately 90,000 h.p. per square mile of tidal basin area, or, with storage, to give a continuous 24-hour output of 2,200 h.p." In the Severn estuary, the tidal range is of the amount contemplated by the authors, and supposing an area of 20 sq. miles brought under operation, an average daily output of 8,000,000 h.p. could be reckoned upon, or of about 60 per cent. of this with storage, adequate to give a continuous output. Since the power to be obtained from a tidal basin depends on the square of the tidal range, it is natural to seek a site where the range is at a maximum, as the unit cost of installation per horse-power will be smallest where the tidal range is greatest. But such a choice carries with it the disadvantage of relatively great fluctuations of head, and this variation would be very considerable if the turbine operated on the rising and falling tides, which theoretically seems to be the most economical method of working. In such a case, the head would be twice as great at springs as at neaps, and the energy output would be consequently four times as great. Improvements in the construction of hydraulic turbines may of course be anticipated, but with large variation in working head, it is difficult to imagine a turbine that will maintain constant speed with high efficiency at a rapid rate of rotation. Further, the possibilities of the silting-up of the estuary and the consequences of disturbing the *régime* of the river, may prove of greater economical importance than the design of the turbine and other questions of a subsidiary character. But we are quite certain, that when the world is ripe for the adoption of such a design, when complete answers have been found to the problems awaiting solution, the enterprise of engineers will carry the scheme to a successful issue.

But for many years, experience will have to be acquired in foreign and colonial stations, and in order to give the greatest assistance to those likely to be engaged in actual operations, the authors have adapted their work to the very varied conditions of actual requirements, embracing all the diverse matters to which the engineer will have to devote his attention. The measurement of rainfall and of the amount of run-off will early occupy him, for it is mainly on these factors that the possible installation of any new hydro-electric scheme depends. The range of uncertainty in the amount of water available must be very great, however long a period is covered by precipitation statistics. The ingenious methods of Verménte and others for deducing the monthly run-off from a knowledge of the monthly rain-fall and evaporation, by taking into account the effect of ground storage, are apt to prove misleading, especially when the data are limited to only a few years—a minimum of seven is suggested. But it is very unlikely that extreme values would be found in so limited a period, and indeed instances are known in America, where conclusions the most carefully derived from short intervals, have been overthrown by experience gained within a few years of actual working. To assert, where no artificial storage exists, that the maximum power developable depends upon the minimum flow may be strictly justified, but would underrate the plant capacity which may be profitably installed, and indeed the authors go so far as to recommend, that the extent of the installation might be assumed at three or four times the minimum stream flow, any deficiency being made good by fuel power plants as auxiliaries. A combination of steam and water power plant often forms the most economical method of using water power, and this fact has been amply recognised in the United States. The rule given by the Water Power Branch of Canada for determining the size of the installation is rather elaborate, and seems to underrate the power available, but is no doubt warranted and applicable to severe climatic conditions.

The subject of hydraulics, properly so-called, is introduced by the consideration of the flow of water through pipes, in open channels, and over wires, many familiar formulæ being encountered. These, from the nature of the condition, can be only approximate, but their limitations are well understood. Some new authorities are quoted, but the forms given by Chezy, by Kutter and by Bazin, are generally maintained, the numerical values of the constants being changed. On pipe lines, Mr. A. A. Barnes has added a new factor, depending on the age of the pipe, which deserves attention. With an asphalted cast-iron pipe of diameter 40 in. to 44 in., he writes:

$$\text{Percentage diminution in discharge} = 13\,(\text{age of the pipe in years})^{0\cdot37}.$$

thus reducing the available diameter 30 per cent. in ten years, and 39·4 in twenty years. The rate of diminution is much less in a wooden pipe, and these on account of the very low friction losses are growing in favour especially where good native timber abounds. The obvious lesson conveyed is the

necessity of providing a pipe to give an initial discharge in excess of requirements.

The civil engineering problems, on which Mr. H. D. Cook writes, embrace the construction of dams and of all the works necessary for drawing the water from the storage, basin or river, to the pipes or other water conductors, and finally to the delivery at the turbines. Of dams, there are many types, and in each type variations of construction, the selection of which is determined usually by local circumstances. But each needs special precautions to secure permanency, and low charges for repairs, and the details to secure this desirable end are set out very clearly. Abundant instances of admirable construction can now be furnished from America and Canada, irrigation work in the former country has afforded much experience, and the provision of power plant in the latter offers many excellent models. The author has availed himself of examples drawn from both sources, and added others of European design, which illustrate accessories provided to ensure economic working conditions. Between the storage reservoir or the river, as the case may be, and the final destination of the water, arrangements must be made for the intake, with the necessary gates and valves and for water conductors to the turbine, by either a canal or flume. If a closed waterway is desired, a tunnel or pipe line becomes necessary. The various forms are very fully illustrated, and are more than sufficient to give an excellent idea of the general conditions that obtain, but those actually engaged in the work of construction cannot dispense with the descriptions of new works given in the technical journals. The general arrangement of the station, the choice of apparatus, and the factors that limit choice, are discussed in a separate chapter, though there seems no sufficient reason for dividing this section from that devoted to constructional work.

The intervening chapters on Turbines and their Speed Regulation are by Professor Gibson, whose views will be heartily welcomed as those of an eminent authority. While emphasising the acknowledged pre-eminence of the Francis turbine, in which the guide vanes surround the outer periphery, he anticipates a partial return to the Jonval type, where the guide vanes are above the runner and the water flows axially into and through the wheel, or if this degree of atavism may not be reached, he predicts that the standard low head, high-speed turbine of the future will differ very appreciably from the Francis type. Any competition between the Pelton wheel and the reaction turbine is not probable, the one being eminently suited for high heads, moderate speed of rotation, and small volume of water, while the reaction turbine with its full peripheral admission, is well adapted for large volumes of water for its relatively high speed enables reasonably high rotative speeds to be obtained with low heads. The theory of the turbine and Pelton wheel is considered very fully, and Professor Gibson has the advantage over his colleague, inasmuch as his mathematics will not vary by time or be overthrown by experience, whereas constructional work continuously improves, and the outcome of to-day is rendered obsolete by the ingenuity of to-morrow.

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Business with Spain.—German trade propaganda is very active in Spain, and German commercial travellers are to be seen there as busy as before the war. German trade papers in the Spanish language are circulated widely among the commercial community. British publications are usually in English and are therefore of limited use.

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Exhibition of American Architecture.—This exhibition, organised by the Royal Institute of British Architects, was opened yesterday at the Galleries of the Institute, 9, Conduit-street, W. 1, and is to remain open until December 9. The hours are from 10 a.m. to 5 p.m., Saturdays 10 to 1. A meeting takes place to-day at the Institute, when Mr. B. G. Goodhue and Mr. D. Barber, both American architects, will deliver addresses. Mr. R. Unwin will deliver a lecture on "American Architecture and Town Planning" on Tuesday, the 29th inst., at 6 p.m. Admission to exhibition and lectures is free.

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National Certificates in Chemistry.—The Board of Education has issued particulars ("Rules 100") of the arrangements and conditions for the award of National Certificates in Chemistry to students in technical schools and colleges in England and Wales. Further information can be obtained from the Registrar, the Institute of Chemistry, 30, Russell-square, W.C. 1.

## PUBLIC WORKS, ROADS, AND TRANSPORT CONGRESS.

Concurrently with the Exhibition now being held at the Agricultural Hall, Islington, to which we refer elsewhere, a series of conferences has been arranged covering a variety of subjects. These conferences were organised by different bodies, the Institution of Gas Engineers opening with morning and afternoon meetings on Friday, the 18th inst. On Saturday last the Institute of Cleansing Superintendents arranged a meeting, and on Monday, the 21st, a conference of County Land Agents was held. On Tuesday, the County Councils Association, jointly with the Association of Municipal Corporations and the Urban and Rural District Councils Associations, held a conference, this being followed on Wednesday by one organised by the Institution of Municipal and County Engineers. Yesterday was the turn of the British Waterworks Association, and to-day, Friday, the Incorporated Municipal Electrical Association is in session.

With so many bodies responsible for the conduct of these meetings, it is only natural that the subjects covered should have been very numerous and diverse. In fact, several of them are completely outside our field, and if we do not refer to many of them the reason must be understood to lie in this fact, and not in any wish to imply that they have little intrinsic value. Again, with such a diversity of subject it has somewhat naturally followed that a certain amount of clashing has occurred, and in some instances we have found it necessary to group subjects rather than deal with each day's proceedings in sequence.

### Public Lighting.

At the conference of the Institution of Gas Engineers a paper was read by Dr. J. S. G. Thomas and Mr. Dean Chandler on "Public Lighting by Gas." In this paper the authors deprecated the complication of units by the introduction of such terms as the lux, the phot, &c., considering that candle-power and foot-candles were sufficiently definitive. They, however, curiously enough, immediately suggest that the unit termed a foot-candle unit should be designated a Murdock, following the custom in other sciences of commemorating pioneers, which scarcely leads, we think, to simplification. Brief consideration was given to the question of public lighting, as affected by national fuel resources, cost compatible with adequate service, glare, steadiness, &c. Sir Dugald Clerk and Professors Smithells and Cobb are quoted as authorities for the statement that as regards national fuel economy there was little to choose between gas and electrical energy, though for most operations involving the utilisation of energy for the production of heat, light and power, fuel resources were best conserved by their utilisation in gaseous form. On the question of glare the authors point out that this effect is usually traceable to unscreened rays or the intrinsic brilliance of the source of light. Figures given in the paper show the intrinsic brilliance in candle-power per square inch of the sky to average 2·5, high-pressure incandescent gas burners 400, and electric lamps anything up to 20,000. The effect of glare is avoided if the actual source of light is screened. On the extension of gas lighting the authors referred to the changes shown by the records of the South Metropolitan Gas Company. These indicated that between 1899 and 1913 the candle-power per cubic foot of gas per hour increased from 2·5 to 19, at the later date 8,000 inverted incandescent burners being in use. The latest type of gas lamp was described, with a cluster of three inverted mantles, in which the gas and air consumed are both preheated to a considerable amount. The hourly consumption of such a light is 0·035 of a therm, and the mean candle-power (Mean per therm × consumption) 229. This lamp gives exceptionally even lighting, with absence of glare.

### Benzole.

"The Utility of Benzole for Transport Purposes" was the title of a paper read by Captain E. de Normanville, also at the Institution of Gas Engineers' Conference. This paper took up the subject of benzole for transport purposes with the object of setting forth its advantages in the directions of increased power or mileage, absence of pinking, economy, sweeter running, and the fact that it was home produced. Benzole can claim 20 per cent. more thermal energy per gallon than petrol, and with this fuel it is not so necessary for some reason to retard the spark, so that power can be better maintained. On the question of economy the author quoted instances of increased mileage amounting to 30 per cent. on motor bicycles, and drew attention to the need of suitable lubrication. In this connection he gave the temperature of the sump chamber of a car engine as 90 deg. to 200 deg. F., of the cylinder walls 180 deg. to 350 deg. F., piston walls 200 deg. to 400 deg. F., and piston heads 300 deg. to 1,000 deg. F., with the temperature of explosion between 2,000 deg. and 3,000 deg. F. The lubricant employed should have a mineral base, as benzole tended to encourage sedimentation with animal or vegetable oils. From the economic point of view unfortunately it meant that the consumer would have to pay more for his gas if the output of benzole were to be increased in gas works, and it was hardly a commercial proposition at present for gas works to recover it.

### Atmospheric Pollution.

It will be remembered that at the British Association meeting held in Edinburgh, in September, Dr. J. S. Owens read a paper, subsequently reprinted in our columns (page 555 *ante*) on "Suspended Impurity in City Air." At the conference last Friday, Dr. Owens presented a supplementary paper, discussing the "Reduction of Atmospheric Pollution resulting from the Use of Gaseous Fuels," and referred to statistics based on investigations of conditions in Glasgow and London. London showed quite a distinct fall in the amount of solids contained in the atmosphere between 1916 and 1921, during which time the gas cookers and other appliances in use increased from about 1,312,071 to about 1,430,942. Curves plotted for Glasgow also showed a distinct correspondence between the pollution and the gas appliances in use. Dr. Owens pointed out that so far as economy was concerned the user of a fire secured so little direct economy by the elimination of smoke at a fire, that the subject often had little attraction, and more would be done towards abolishing unsatisfactory conditions of fuel consumption if the public were made aware of the dangers of polluted air.

### London Refuse.

At the meeting on Saturday morning a paper was taken which is somewhat outside our field, but brings forward a proposal, which, if realisable, would do a good deal to effect economy in handling the refuse of London, which amounts to about 5,000 tons a day. The author, Mr. W. J. Heavey, pointed out that there are authorities owning riverside or canal wharfage at which their refuse is shipped, whose transport passes through at least two other boroughs also possessing wharfage of this type. Between two of the London bridges five councils tip refuse at five wharves, whereas part of this accommodation only would suffice if combined. Local boundaries run down streets and different authorities work over the same ground, and often contractors work in the same street alongside the employees of an adjacent council. Mr. Heavey's proposal is that all this work of refuse collection and disposal should be co-ordinated, and if the whole were contracted for he estimates a saving to London of 250,000*l.* per annum.

### Unemployment Relief Works.

The meeting held in the morning of the 21st inst. was devoted to a discussion on "the advisability of formulating in advance schemes of a definite character in connection with public works, with a view to such schemes being undertaken expeditiously during cycles of trade depression." The chair was taken by Sir H. P. Maybury, K.C.M.G., and the subject was introduced by Alderman J. Rimmer, J.P., of Bolton, who remarked that the discussion was not intended to deal with the alleviation of suffering due to unemployment at the present time, but to put forward the necessity for the preparation of large schemes which could be commenced as soon as the necessity for providing work arose in the future. Unless such schemes were prepared work was likely to be put in hand hurriedly and without sufficient consideration. The main difficulty, Mr. Rimmer said, was a financial one, but he thought this might be overcome, and suggested that if the Government and the municipalities arranged for the provision of money in times of prosperity, the burden of rates and taxes would be much lighter. Funds so collected would accumulate and would be ready for disposal when required. The chairman, Mr. Rimmer continued, wished the Organising Committee of the Congress to remain as a permanent committee, and the speaker thought that if this could be arranged, the committee would be a suitable body to deal with the matter under discussion. He understood that the Government was in sympathy with the idea and had already adopted it in a small way.

The first speaker in the discussion was Colonel Sinnott, who said that matters would be greatly facilitated if the Labour Ministry would indicate to local authorities in which areas they considered unemployment sufficiently acute to make grants for relief works, and Mr. Norman Scorgie, who followed, spoke in favour of the suggestion, and added that the matter was one of national importance and must be considered by the Government of the day. Mr. Meade-King, the next speaker, said that works for preventing coast erosion offered means for providing employment, as also did afforestation and road improvements. Mr. A. E. Brookes remarked that the County of Durham had had under consideration for many years a scheme for the construction of a road connecting the Hartlepools with a large colliery district. The work had,

however, to be started in a hurry and at first proved to be more costly than has been anticipated. After other speakers, including Mr. S. Marsh, ex-mayor of Poplar, Alderman Duff, of Belfast, and Councillor Bolus, of Berwick, had spoken, a resolution to the effect that the Government in conjunction with the public authorities of the country should without delay, and with a view to providing work during cycles of depression, give instructions for the preparation in advance of schemes of a definite character so that such schemes may be ready and be put in hand when such periods arise, was proposed by Mr. Scorgie. The resolution was duly seconded, and the chairman, in speaking to it, referred to the scheme for the construction of arterial roads in the London area which was under consideration before the war with the result that an incomplete plan was formulated. The plan had, however, enabled some of the work to be put in hand during the present crisis. He also mentioned that a scheme for the construction of a new road between Liverpool and Manchester was under consideration, but said that a special Act would be required before this work could be proceeded with. Coast defence work and afforestation, Sir Henry did not regard as very promising for relieving unemployment, and there were many difficulties in connection with canal improvements which had been suggested by one speaker as a possible source of work. Colonel North and Mr. Rimmer also spoke in favour of the resolution, which was afterwards carried unanimously.

### Road-Making.

Road-making formed not unnaturally the subject of several papers at the various meetings. One on the subject of tar was introduced at the Institute of Gas Engineers meeting, another dealing with road-making plant was taken on Tuesday at the meeting of the County Councils Association, a third was considered on Wednesday by the Institution of Municipal and County Engineers, and still another was read yesterday. Each of these, it is true, considered special branches of the subject. Mr. Hugh James' paper, on Friday, on "Coal Tar for Road Work," discussed this material from the point of view of the producer. There were plenty of specifications, he said, laying down the views of the user, but he wished to bring home the need of co-operation between the distiller and the highway engineer, and wanted to lay down broad lines of foundation, such as absence of water, the grading of tar according to consistency, and to secure simplification. He pointed out that "free carbon" was not necessarily a disadvantage in tar, and that in any case fillers were often used. It was only when grit and dust penetrated into tar on the road that the result was satisfactory, and a tar deficient in insoluble substances did not give good results until this change occurred. With regard to cutting back, this he thought should only be done with the highly viscid liquids obtained at the upper end of the distillation process, otherwise the tar mixture would not penetrate in grouting—only the mobile portion being absorbed while the insolubles remained as an external coat. There should be no upper limit to the specific gravity, therefore, of the oils used for cutting back. The use of viscosity should be replaced by "consistency" as measured by the Hutchinson instrument, which, though based on no scientific unit, yet provided a reliable test. In this test the rate at which the instrument sinks in the tar at 77 deg. F. is measured. The presence of water and ammoniacal compounds in tars for road-making were fatal to success. Specific gravity of a tar was no criterion of its fitness for road-making, as tars of very different compositions would be found to have the same specific gravities. Mr. James also protested against the British Engineering Standards Association's definition of bitumen in the specification of road-making materials, stating that the attitude there adopted could be interpreted to mean that only those particular types of bituminous binding gaents suitable for road work should be classed as bitumen in future, an altogether unjustifiable imitation from the chemists point of view, as Mr. James pointed out.

"The Care and Upkeep of Road Appliances" formed the subject of a paper by Mr. H. T. Chapman, county surveyor of Kent, taken on Tuesday morning. In this paper, Mr. Chapman described the organisation possessed by the County of Kent for the repair of its own vehicles engaged on road work, &c., including shops capable of dealing with repairs on rollers, tractors, steam wagons, lorries, cars, crushing plant, mixers, &c., in addition to building trailers, hand carts, &c. The discussion which followed this paper turned largely upon three points, namely, the best way of recording the performance of rollers and wagons, &c.; the necessity or otherwise of a transport officer; and thirdly the point at which the establishment and organisation of a repair depôt became advisable. With regard to the first point, opinion appeared to be divided as to whether, in view of the unequal hauls, the unavoidable light running owing to absence of return loads, and so forth, it was most practical to keep records by the day or per ton-mile. In some cases both are kept, but all speakers agreed that the whole question needed thorough investigation with a view to putting statistics on a proper and uniform basis so that figures from different districts might be compared, and it could be known definitely what they included.

With regard to the transport officer it was admitted that the amount of work involved in organising the traffic of a large road-repairing department occupied much valuable time, often more than could be properly devoted to it, but it was considered difficult to prove that actual saving would result from the introduction of such an official. The general view appeared to be that the mechanical upkeep of all appliances should be in the hands of one man, whether in the shops or out in the district, while the work got out of the machines should be arranged for by another official. Variations of this arrangement were mentioned. The actual point at which the establishment of a repair depot, and the form it should take, was largely a matter of local conditions. They had to guard themselves against any charge of municipal trading, but on the other hand the cost of repairs was not always the decisive factor. Often the time the machine was out of one's control, if the work were done by contract, was far more important, and the concensus of opinion appeared to be that for a department of any size it was economical for it to be in a position to do running repairs on a reasonable scale.

Among other points raised in the discussion was the question of trailers. For some districts these were advocated; in others it was pointed out they were impossible, while the need of having duplicate trailers to avoid loading delays at terminals was also noticed. In connection with loading it was stated that at Grimsby sanction had just been obtained for the erection of overhead bins for storing road metal, &c., arriving by railway truck. In order to abolish the waste of time standing while the material was shovelled out of trucks into wagons, it would now be shovelled into the hopper of a movable elevator, at door level, and would by this machine be lifted to bins from which it could be shot into the wagons in a few minutes. Several tributes were paid to Sir H. Maybury for affording the authorities the opportunity of purchasing road machinery returned from France at reasonable prices. One speaker incidentally mentioned that he thought 2 miles to 2½ miles the minimum haul for which mechanical transport was warranted, and that while he had machines he had arranged to use horse carts on a large job where the haul was short. Various speakers touched on the relative merits of steam and petrol lorries, the bulk of opinion still siding with the former save in exceptional circumstances, as instanced by Colonel Sinnott, of Gloucester, who said he used petrol lorries in the Cotswolds where water was often scarce, and coal had to be carried a long way.

The hopeful note struck in Mr. W. J. Hadfield's paper, entitled "Optimism in Road Making," which was taken on Wednesday afternoon, was favourably commented on by several speakers in the discussion. Mr. Hadfield, who is City Engineer for Sheffield, early tackled the question of improving the roads in Sheffield, and the results he embodied in his paper go to show that without any addition to the rates the roads have been brought up to modern standards. The total expenditure per mile of highway for Sheffield averaged for the five years ending with 1910, 251*l.* The estimate for the current year is 268*l.*—a result brought about, in spite of the enormous increase of heavy traffic, by the use of material with long life. Mr. Hadfield's conclusions are that a good water bound road, 6 to 8 yards wide, tar sprayed or painted, can stand 400 to 600 tons of mixed traffic per day; for roads 8 yards wide carrying 80 to 100 'buses, tar macadam on a sound foundation is economically satisfactory; for roads with 3,000 to 4,000 tons per day clinker-asphalte or a similar surface is sufficient. The latter has been utilised largely in Sheffield, and the author quoted one instance, where the traffic amounted to 6,000 tons, having been put down four years ago and showing no sign of deterioration. Wood paving had been replaced by this material with good results.

The discussion on this paper raised a good many points, one being that, while the results were good, such work might be possible in a town but was not possible in the country districts. It was a question ultimately of rateable value, and while in one area a 1*d.* rate might raise 20,000*l.*, in another it would only result in a few hundreds, so that expensive work was out of the question, especially if the necessary material was only procurable at a distance. In fact, a warning was raised by more than one speaker that the author's figures for cost of material should not be taken as averages capable of common application. Several speakers urged the importance of obtaining more assistance from the Ministry of Transport with regard to roads on which heavy 'bus and other traffic had developed, which normally were not regarded as through roads. For the improvement of these the local authorities could not provide the funds to bring them up to the classification standard of second-class roads, without which they got no assistance. Mr. Robinson, of Hackney, raised a point which possibly should have been made at a later meeting. As an electrical engineer, he spoke as a user not only of the road but of the ground under the road, and said the exhibition had filled him with dismay because of the display made of reinforcing material for concrete roads. He thought that after the author's great results with clinker, he, as a producer of about 16,000 tons of clinker a year (being in charge of the borough destructor), should be easily able to dispose of this material to Mr. N. Scorgie, Borough Engineer of Hackney, who happened to be in the chair.

Mr. H. James, of the South Metropolitan Gas Company, spoke on the quality of tar, mentioning several points of his paper of Friday last when the paper did not, as had been hoped, attract the notice of many road surveyors. These points are referred to in our summary above. Mr. H. T. Chapman said that all producers of tar had not treated them well in the past and prices had been, he thought, rather excessive. He welcomed the competition between oil and tar products. It was remarked that both these, according to Mr. Hadfield, had a distinct field.

The treatment of roads by tar was referred to by Mr. Spillman, of Brigg, who instanced a road laid with slag in the centre and whinstone at the sides, the whole being rolled, and then tarred and dressed with granite chippings three times. The road was subjected to heavy traffic but did not suffer. Speaking as a farmer, however, Mr. Spillman said the horses were not growing used to tar surface roads. Sir Robert Usher on this point said that now in Midlothian they tarred the whole road, but on the sides, while hot, they spread and rolled in a thick layer of ¾-in. granite chippings, and thus the trouble had been greatly reduced. Mr. Gettings in this connection drew attention to the report on slippery roads by the Ministry of Transport referred to elsewhere in this issue (see page 733). A warning was also raised with regard to the author's figures by Mr. Horton (Derbyshire County Council), who said that the average figure of cost taken alone might mean anything, because such a cost could be maintained though expense was heavy in one direction by cutting it down in others. It was generally agreed, however, by the meeting that Sheffield had the benefit of good roads which were well, and under these circumstances it would appear that Mr. Hadfield's figures, which included revenue expenditure, capital expenditure and grants, were satisfactory.

On another point Mr. Horton drew attention to the fact that in replacing wood blocks by a clinker-asphalte a good foundation of concrete was already in position, but that to bring the surface to the right level a filling of rubble had to be used between the two. This had apparently been done without any ill effects. In towns they had also the advantage of good kerbs, whereas in the country kerbs did not exist and had to be put in if asphalt roads were laid.

At a meeting yesterday morning a paper on "Reinforced Concrete Roads and their Relation to the Laying and Maintenance of Water and other Service Mains" was considered. This paper was by Mr. C. G. Henzell, water works engineer of Leeds, who said, as far as he could see the only solution of the problem, if reinforced concrete roads were insisted upon, was the provision of subways on both sides of the road, because it was almost impossible to lay connections across the street under the reinforced roadway. The subways would have to be at least 5 ft. 6 in. clear height and the thickness of cover, with reinforcement, at least 9 in., to stand the traffic. On account of cellar rights, &c., it would not be possible to place them wholly under the footpaths, but they should project under the road as little as possible. Accommodation should be provided for all mains under 12 in. in diameter. Those over that size should be laid in the roadway, and troubles of leakage, connections, &c., would still remain. Every department concerned would expect room for extensions. At crossings complications would be numerous, but would have to be faced. The use of such subways would necessarily increase the cost of service, as both duplicate mains and subways would be necessary, but a saving would be realised by obviating the necessity of breaking up the road surface and relaying. The only alternative, and that only in new districts, to subways, appeared to lie in having very wide causeways or green verges sufficient to provide space for all service and trunk mains. Mr. Henzell suggested a conference on the subject between representatives of water, gas and electricity services with a view to joint action. This, we think, would be to the interest of the road engineer as well, as no engineer who places any reliance upon reinforcement he thinks it advisable to put into concrete can remain indifferent to seeing it cut through and possibly never bonded up properly again, all for the sake of finding and repairing a fault in another person's pipe.

# THE MACHINERY OF FLOATING DOCKS.*

By E. H. Salmon, D.Sc., of London.

The floating dock has long since established its position as one of the most widely used appliances for docking ships. Nevertheless, with the exception of an occasional article in the technical press, it is believed that since the papers read before the Institution of Civil Engineers in 1905† and the Institution of Naval Architects in 1907‡, by Mr. Lyonel Clark, with whose name the development of the modern floating dock will always be connected, no memoir on the subject has appeared. Even in the papers quoted, very little reference was made to the machinery of floating docks, so that a paper dealing with what has been done in this direction may be of interest to engineers.

The subject may be divided into four parts:—

1. Pumping machinery.
2. Control gear.
3. Auxiliary machinery.
4. Berthing gear.

## (1) Pumping Machinery.

The floating dock in its essentials is a hollow steel box of U or L-shaped cross-section. This box is sunk to some desired depth by letting water into the interior, and while in this sunken condition the ship is hauled on to the pontoon or horizontal limb of the U or L. Water is then pumped out from the dock, which causes it to rise, carrying, of course, the ship with it, the operation being continued until both ship and pontoon deck are high and dry. The function of the pumping machinery is to remove this water. Alternatively, arrangements must be made for admitting water at will.

The magnitude of the problem in a large dock may be better judged when it is stated that some 60,000 tons of water have to be removed from an area of 11,000 sq. ft., that is, 2¼ acres, requiring 10 pumps of 20 in. diameter of outlet, running for 3 hours, each driven by an engine or motor developing some 200 h.p.

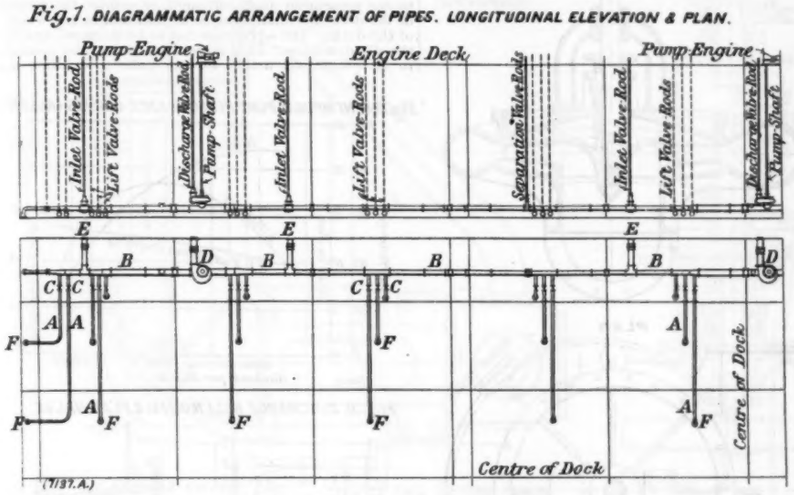



Fig. 1. DIAGRAMMATIC ARRANGEMENT OF PIPES. LONGITUDINAL ELEVATION & PLAN.

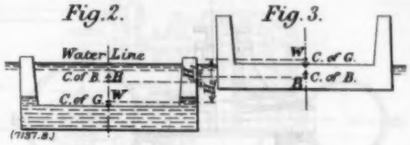



Fig. 2.




Fig. 3.

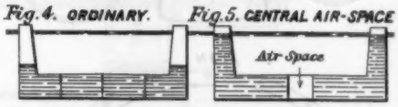


Fig. 4. ORDINARY. Fig. 5. CENTRAL AIR-SPACE



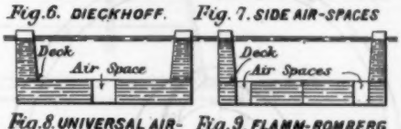



Fig. 6. DIECKHOFF. Fig. 7. SIDE AIR-SPACES

Fig. 8. UNIVERSAL AIR-SPACE. Fig. 9. FLAMM-ROMBERG



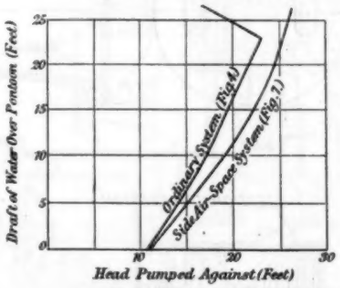




Fig. 10. HEAD CURVES.

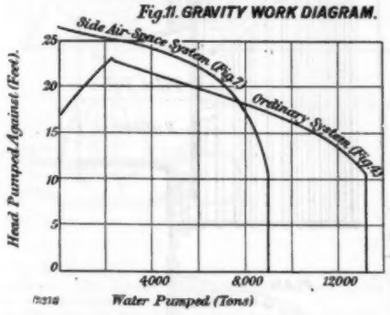



Fig. 11. GRAVITY WORK DIAGRAM.

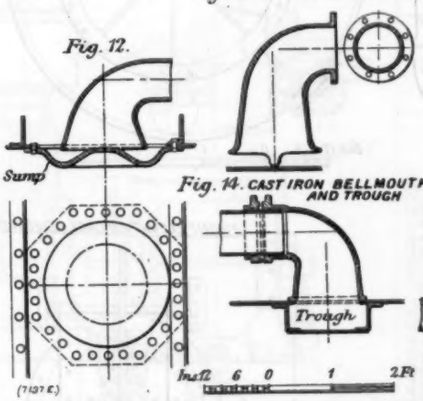



Fig. 12. Fig. 13. CAST IRON BELLMOUTH Fig. 14. CAST IRON BELLMOUTH AND TROUGH

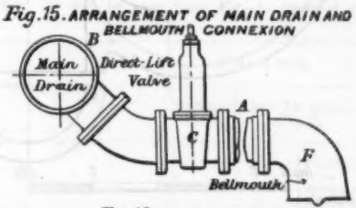



Fig. 15. ARRANGEMENT OF MAIN DRAIN AND BELLMOUTH CONNEXION

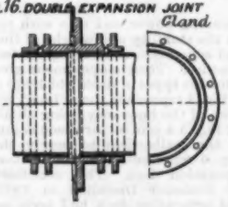



Fig. 16. DOUBLE EXPANSION JOINT

This operation of pumping out a floating dock differs from that of pumping out a graving dock or similar structure, in that the floating dock has always to be maintained on a level keel. To obtain this balance, the dock is subdivided in both directions into a number of compartments, from any one of which water can be removed at pleasure. The whole operation must be under the complete control of one man at a single control station. Similarly, while lowering the dock, it must be possible to admit water into any desired compartment.

The usual system of pipes and valves adopted to effect this control consists of a gridiron arrangement of pipes A, A, one leading to each compartment from a continuous main drain B B, Fig. 1. Each compartment-pipe is governed by a direct-lift valve C, C, operated from the control station. The pumps D, D, draw from the main drain, and the inlets E, E, deliver into the same. Each inlet and pump discharge is governed by a screw-down valve on the sea side. In this manner it is possible to fill or empty any single compartment at will, and the dock is completely under control.

In very small docks there may be only one main drain and one pump, in large docks several separate systems, each with its main drain and pump, or pumps. These separate systems are usually inter-connected, so that the pumps of one system can, if desired, draw from the main drain of the others, suitable valves being introduced. In this case, should one pump break down, it is still possible to raise the dock, though of course in a proportionately longer time.

The size and arrangement of the compartments is usually determined by questions of stability, and, in some degree, of convenience in handling. To these considerations the pumping arrangements have always to be subservient. In modern docks, however, a great deal of attention has been paid to the arrangement of the compartments, and particularly to the introduction of sealed compartments or air chambers into which the water is never allowed to enter, with the idea of reducing the work done, and the amount of water pumped in raising the ship and dock. To understand this question it is first necessary to consider a little in detail on what the work done and water pumped depends.

Fig. 2 represents the dock in its sunken condition. Two equal and balanced forces act on the structure, namely, its weight W acting at the centre of gravity, and the upward buoyancy B equal to W acting at the centre of buoyancy. Fig. 3 represents the dock raised with the pontoon deck awash. The same two equal forces occur, but their relative position is different. Now, the work done in raising the dock is evidently the weight W times the distance it moves, minus the buoyancy B times the distance it moves, that is—

$$\text{Work done} = W \times H_2 - B \times H_1 = W\,(H_2 - H_1),$$

since W = B. Evidently, therefore, if $H_1$ could be increased by lowering the centre of buoyancy in Fig. 2, when the dock is sunk, the work done could be diminished. The method adopted to effect this is to transfer buoyancy from the vertical caissons, usually called the side walls, to the horizontal caisson, or pontoon proper, by sealing up certain of the pontoon compartments, thus making them into permanent air chambers, Fig. 5, above. Roughly speaking, some 80 per cent. of the dock's weight may be "balanced" in his way, and a considerable saving in horse-power effected.

The amount of water to be pumped is not affected by this device, for it is evident that for every ton of displacement pushed out of water in raising the dock, 1 ton of water must be pumped from the interior. Hence the weight of water to be pumped is equal to the loss of displacement of the dock as it rises (including that of the ship, if a ship is being lifted). This figure depends chiefly on the dimensions of the side wall, and is independent of the weight of the dock and the arrangement of the compartments. Nevertheless, it is not necessary that all the water should pass through the pumps, and, by suitably arranging the compartments, the size of the main drain and pumps may be considerably reduced.

Suppose a watertight deck or bulkhead be introduced, dividing the side wall from the pontoon proper, Fig. 6. If, now, water be pumped from the pontoon compartments, it is evident that, as the dock rises, a position will be reached when the water in the side walls is at a higher level than the water outside. Then it is only necessary to open a suitable valve at the bottom of the wall, and let the water run out as the dock rises. In this way 20 per cent. to 25 per cent. of the water may

* Paper read before the Institution of Mechanical Engineers, on Friday, November 18, 1921.

† "Floating Docks," by Lyonel Edwin Clark, M.Inst.C.E. Proceedings, Inst.C.E., vol. clxi, Part III.

‡ "Modern Floating Docks," by Lyonel Edwin Clark, M.I.N.A. Trans.Inst.N.A., vol. xlix, page 238.

be run in and out of the dock without passing through the pumps at all. There is considerable saving in pipe friction and in the diameter of the pumps and main drain—a useful feature in large docks.

Both these devices are quite well known and by no means new. Rennie, in his patents of 1860 and 1863, shows both the air space and the watertight deck. More recently, however, a good deal of investigation has been made on the effects of fitting air spaces and watertight separation decks, both with regard to saving in pumping power and also with regard to their influence on the stability and weight of the dock. Both air space and separation deck are quite feasible and work well in practice. Their employment gives rise to a number of different types of dock which are shown in Figs. 4 to 9.

Fig. 4 represents the ordinary system with no air space, most of the buoyancy being obtained from the side walls. In Fig. 5 a central air space is introduced, and the water in the walls rises to nearly the external water line. Fig. 6 represents the combination of the air space and separation deck. This combination was brought out by Professor Dieckhoff in 1902, but both air space and separation deck had been used before, both singly and in combination. In Fig. 7, a similar separation deck is used, but the air spaces are placed at the side. In Fig. 8 the separation deck is also employed, but instead of special sealed air chambers, air is left in the pontoon in every compartment. Fig. 9 represents a system known as the Flamm-Romberg, after the name of its originators. It is a variation of the design shown in Fig. 6, the horizontal deck becoming a vertical bulkhead under the face of the wall. This has the advantage that it increases the stability of the system, but from the point of view of pumping machinery its behaviour is almost identical.

Another system sometimes adopted is a kind of halfway house between those shown in Fig. 6 and Fig. 8. In this type, the air vent pipes, which have to be provided in all water compartments to enable the air to escape, are carried down to, say, one-half the depth of pontoon in certain chosen compartments. By this means air is trapped in these compartments, and an air space is automatically provided. The separation deck may or may not be fitted.

The question at once arises as to which is the best of these systems. The answer is that it entirely depends on the circumstances of the case, and very largely on the size of the dock. In small docks it is hardly worth while to introduce the air space at all. In large docks it may be desirable to do so.

At first sight it appears to be an unmixed advantage to reduce the pumping work by, say, 25 per cent., and the diameter of the pumps and main drain to a like degree. Unfortunately, as in so many similar cases, with the advantage countervailing disadvantages creep in. It is evident, for example, that if 25 per cent. less work is done in raising the dock, 25 per cent. less work is stored up in the system when it is up, and therefore 25 per cent. less work can be given out during the sinking operation. Now the work stored up in the system when it is raised, is expended on friction in pipes as the water rushes into the interior while the dock descends. If, then, the stored-up work be reduced, the velocity of the entering water is reduced, and the time of sinking is slower to a proportionate extent. This effect is accentuated if a separation deck be fitted, for then several thousands of tons of water have to be run into the side wall under a very small head. This is a somewhat slow operation, and cannot be remedied by an unlimited increase in the valve area, for then the stability of the dock would be adversely affected. It is not uncommon in pumping up a dock with a separation deck for the dock to carry up with it a considerable body of water in the side walls after the pontoon deck is above water, which water quietly runs out afterwards. In fact, all docks carry up about 4 in. to 6 in. of water all over the pontoon deck as the latter emerges, in spite of the large watershed formed by the ends of the dock and the usual deck drainage system, so that it is not a question of valve area at all.

It is therefore necessary to reckon on a longer time of sinking for a dock with air chambers, particularly if a separation deck be fitted, and in practice this type of dock has undoubtedly the tendency to sink slowly. In many cases this is immaterial. It merely means that the operation of sinking the dock must be started so much earlier. In busy ports, however, where the dock must be sunk at very short notice to lift a vessel, the time of sinking is a more serious matter, and it is not uncommon for a definite time of sinking to be specified. In such cases the advantage of an air space has to be very carefully considered.

A second and more serious objection to the introduction of the air space and separation deck is that it adds to the weight of the dock. It is evident that the framing in the air space is much heavier than that outside. In a large dock the head of water on the bottom under the air space may amount to 60 ft. Secondly, the bulkhead which bounds the air space is very considerably heavier than the normal bulkheads. Against this, the framing in the side walls may be made considerably lighter owing to the separation deck, although, of course, the weight of the deck, no small item, is an addition to the weight of the dock. The advantage has to be balanced against the disadvantage. In a large dock it may be possible to save sufficient weight on the walls to balance the increased weight in the pontoon. In a small dock there are limits to this saving, because it is undesirable to reduce the thickness of the scantlings below the limits which good practice determines for metal work immersed in water, and as a rule the saving in pumping power is made at the expense of considerable increase in first cost. Again, a central air space as a rule involves very wide side compartments, and the width of the side wall has to be increased to obtain the necessary stability. To divide this compartment into two, as for example in the Flamm-Romberg system, doubles the number of compartment pipes and valves, and all the necessary valve gear, with the attendant increase in first cost—again a doubtful expedient.

*Fig. 17.* OLD CENTRIFUGAL PUMP WITH CHANNEL IRON IMPELLER

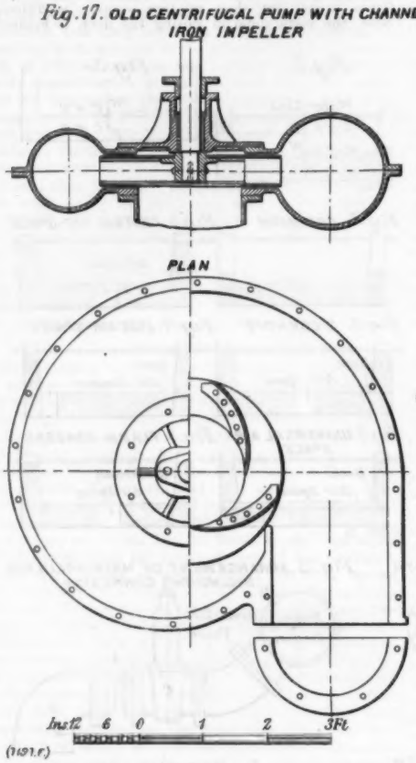



*Fig. 18.* CENTRIFUGAL PUMP. (GWYNNES)

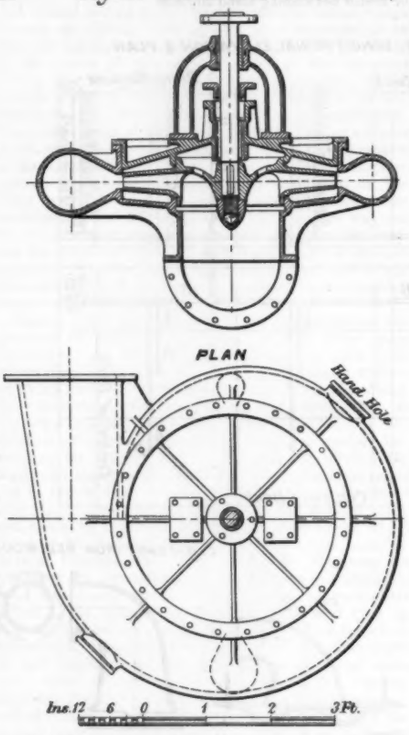



*Fig. 19.* CENTRIFUGAL PUMP PERFORMANCE CURVES. (ALLEN.)

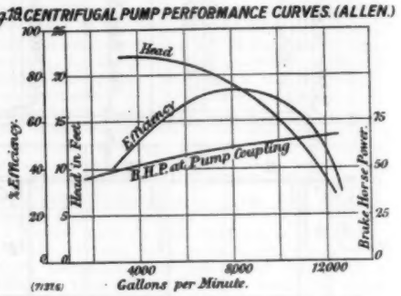
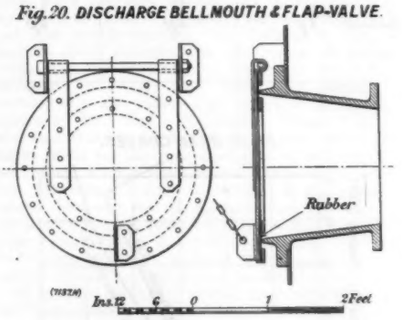



*Fig. 20.* DISCHARGE BELLMOUTH & FLAP-VALVE.



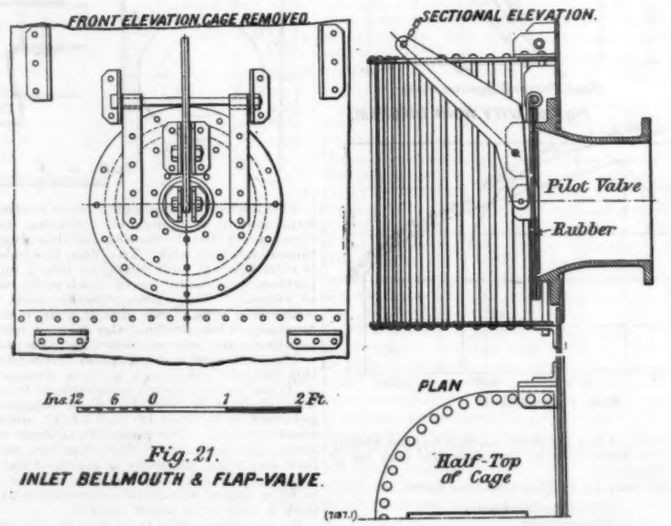




*Fig. 21.*
INLET BELLMOUTH & FLAP-VALVE.

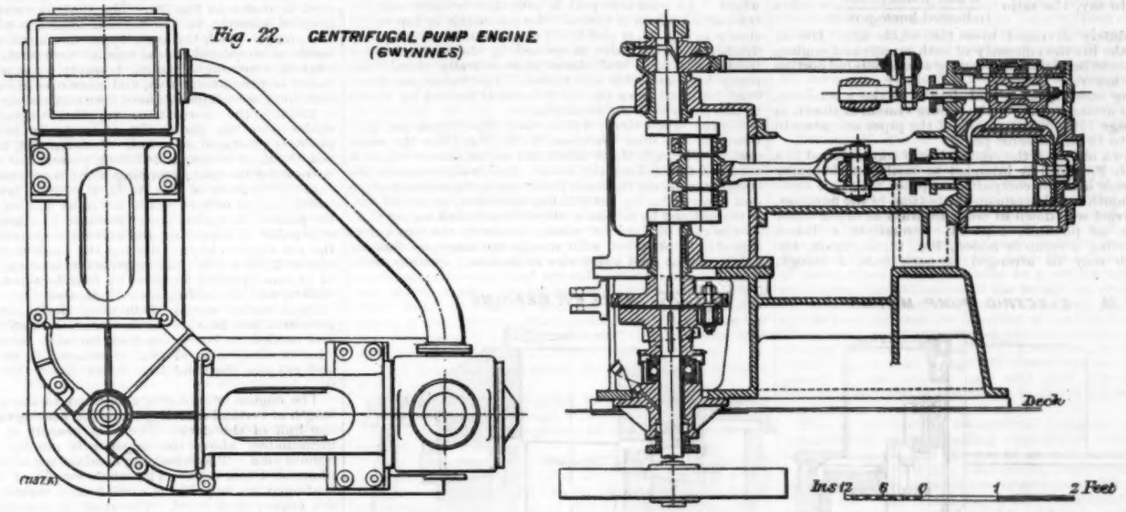
These points are illustrated in Table I, giving a comparison for a 7,500-ton dock of the systems shown in Figs. 4 and 7, page 739. Each had the same internal profile, lifting power, and metacentric height (stability).

Had a central air space been fitted, Fig. 6, the overall width of the dock required to give equal stability would have been increased to nearly 94 ft., with a corresponding increase in the weight and water to be removed.

It should be added that, with the most modern methods of hull construction, the hull weights given could be reduced. Such economies, however, would value at, say, 5 per cent. compound interest of the relative costs of the two systems. Suppose the dock company could borrow money at 5 per cent. per annum. The life of the dock itself may be taken at fifty years, and that of the machinery at twenty-five years. It will be assumed, therefore, that the loan has to be repaid at the end of fifty years. The relative capitalised costs would then be as in Tables II and III below.

It is evident that the non-air space type, Fig. 4, is a far more economical dock than the air space type shown in Fig. 7.

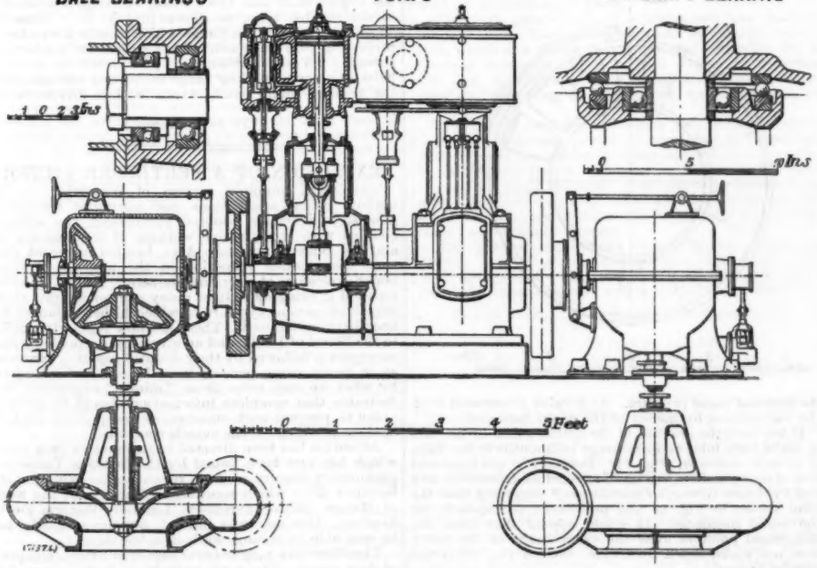
*Fig. 22.* CENTRIFUGAL PUMP ENGINE (GWYNNES)




DETAIL OF ENGINE SHAFT BALL BEARINGS

*Fig. 23.* ENGINE AND CENTRIFUGAL PUMPS

DETAIL OF PUMP SHAFT BEARING




apply to both types, and hardly affect the pumping calculations. The figures form, therefore, a very good means of comparison between the systems.

In a case like the above, therefore, the following considerations present themselves to a prospective dock owner: To introduce an air space and separation deck will increase the weight of the dock from 3,420 tons to 3,640 tons, say, by 220 tons, which at 50*l.* per ton will increase the first cost by 11,000*l.* On the other hand, the indicated horse-power of the engines will be reduced from 300 to 250, reducing the first cost of the machinery by, say, 1,000*l.* Supposing that in a busy port there are 100 dockings per year, each of 3 hours' duration, the machinery will be running usefully for 300 hours per year. There will be saved 50 i.h.p., and if one assumes a figure as high as 4 lb. of coal per indicated horse-power per hour, $50 \times 300 \times 4 = 60{,}000$ lb. = 27 tons of coal less will be burned in one year—a saving of 81*l.* per annum, if coal cost 3*l.* per ton. Suppose the useful life of a dock to be fifty years, then 1,350 tons of coal will be saved at the expense of 220 tons of steel. It is evident that under ordinary circumstances the air space and separation deck are expensive luxuries in such a dock.

Actually, of course, the calculation is not quite so simple. What should be compared is the capitalised

It does not follow that these same arguments apply to all sizes and types of docks, for in certain cases particularly in large docks, economy may result by the introduction of the air space. Briefly put, it depends on whether the air space increase or decrease the hull weight, and to what extent.

Recently, considerable attention has been given to the question of design in order to obtain the advantage of the air space without the disadvantages, and a certain measure of success has been obtained. This is rather a question of hull design than machinery, and beyond the scope of this paper.

The introduction of the air space and separation deck has one consequential effect which has to be taken into account when designing the pumps, and that is that it greatly modifies the shape of the curve showing the heads against which the pumps have to throw. This is illustrated clearly in Fig. 10, page 739, which represents the head curves for the two different types at all positions during the lift. Fig. 11 shows the same curves plotted on a base line showing the amount of water thrown by the pumps.

The area of a curve of the type shown in Fig. 11 evidently represents the work done against gravity in raising the dock. In order to obtain the total work done, the work expended on friction in pipes must be added. This latter is calculated by Unwin's or Weisbach's formula, due allowance being made for bends, changes in velocity and direction, &c. Usually the loss due to friction in pipes is from 10 per cent. to 30 per cent. of the total work, getting larger as the size of the pumping plant increases.

Knowing the total work done, the theoretical or water horse-power of the dock follows at once. To obtain the indicated horse-power, it is necessary to allow for the efficiencies of the pumps and motors or engines. Here a little caution is necessary. The efficiency of the pumps and motors or engines on the test-bed is very different from the efficiency of the same plant averaged over a lift. As will be seen from Fig. 11 there is a considerable variation in the gravity head. True, the increased velocity of output at the low heads tends to level matters up to some extent, in that the frictional

TABLE I.

| | Type of Dock. | | |
|---|---|---|---|
| | Ordinary (Fig. 4). | Side Air Spaces (Fig. 7). | |
| | | | Increase or decrease per cent. |
| Lifting power .. .. tons | 7,500 | 7,500 | — |
| Clear width of entrance .. ft. | 68 | 68 | — |
| Draught of water over keel-blocks ,, | 22 | 22 | — |
| Overall width of dock .. ,, | 91 | 91·5 | — |
| Metacentric height .. .. ,, | 3 | 3 | — |
| Weight of pontoon .. .. tons | 1,790 | 2,090 | +17 |
| Weight of side walls .. tons | 800 | 710 | −11 |
| Total weight of dock, including machinery, fittings and timber, overweight and extras .. tons | 3,420 | 3,640 | + 7 |
| Time of lift .. .. ..hours | 3 | 3 | — |
| Work done against gravity ft.-tons | 243,100 | 205,300 | −15* |
| Work spent on friction in pipes ,, | 39,600 | 31,400 | −20 |
| Theoretical horse-power required.. | 117 | 98 | −16 |
| Indicated horse-power required .. | 300 | 250 | −16 |
| Water removed from dock tons | 13,200 | 13,300 | + 1 |
| Water pumped from pontoon ,, | — | 9,000 | — |
| Water run out from walls .. ,, | — | 4,300 | — |
| Diameter of pumps .. .. in. | 21 | 18 | — |

* There is, of course, a corresponding reduction in work done in raising the dock light after refloating the ship.

TABLE II.—*Air Space Dock.* (Fig. 7).

| | £ |
|---|---|
| Capital necessary to repay 11,000*l.* (the extra cost of the steel work) in fifty years, at 5 per cent. compound interest .. .. .. | 960 |
| Interest for fifty years on 11,000*l.* at 5 per cent. = 550*l.* per annum, capitalised at 5 per cent. compound interest .. .. | 10,040 |
| Upkeep charges for fifty years at 1 per cent. on 11,000*l.* = 110*l.* per annum, capitalised at 5 per cent. compound interest .. .. | 2,010 |
| Total extra capitalised value if an air space be fitted .. .. .. .. | £13,010 |

TABLE III.—*Non-Air-Space Dock.* (Fig. 4).

| | |
|---|---|
| Capital necessary to repay 1,000*l.*, the extra cost of the machinery, in fifty years, at 5 per cent. compound interest .. .. .. | 87 |
| Capital necessary to produce 1,000*l.* at end of twenty-five years to replace the machinery, at 5 per cent. compound interest .. .. | 296 |
| Interest for fifty years on 1,000*l.* at 5 per cent. = 50*l.* per annum, capitalised at 5 per cent. compound interest .. .. .. | 913 |
| Upkeep charges for fifty years (repairs and renewals) at 3 per cent. = 30*l.* per annum, capitalised at 5 per cent. compound interest | 548 |
| Capitalised value of the extra coal consumed = 81*l.* per annum at 5 per cent. compound interest .. .. .. .. .. .. | 1,480 |
| Total extra capitalised value if no air space be fitted .. .. .. .. | £3,324 |

head is correspondingly increased, but nevertheless the efficiency over a large part of the lift is bound to be reduced. Not only so, but towards the end of the lift it is almost inevitable that the pump will draw a certain amount of air, which again tends to destroy its efficiency.

Now, in a calculation based on the total amount of work done, it is necessary to allow for the average efficiency in order to get the average horse-power, and it is found in practice that this average efficiency is for the pumps about 55 per cent., for the shafting, say, 95 per cent., and for the engines from about 75 per cent. That is to say, the ratio $\frac{\text{Water horse-power}}{\text{Indicated horse-power}} = 0{\cdot}4$ approximately averaged over the whole lift. During parts of the lift the efficiency of both pumps and engines will no doubt be higher, but during a considerable portion it will be lower.

Turning now to the actual details of the machinery, the usual arrangements of the piping system is shown in Fig. 1, page 739. Some details of the pipes are given in Figs. 12 to 16 on the same page.

As shown in Fig. 1, the compartment pipes, A, end in a bellmouth F, which is intended to facilitate the entry of the water into the compartment pipe. In some cases the bellmouth merely rests on the bottom of the pontoon, being carried well down in order to drain as much water therefrom as possible, Fig. 13. Sometimes a dished plate forming a sump is added, Fig. 12, or, again, the bellmouth may be arranged to suck from a trough,

*Fig. 24.* ELECTRIC PUMP MOTOR

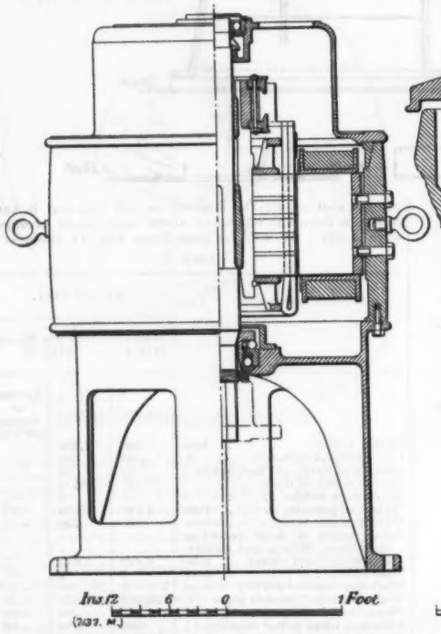



*Fig. 25.* ROLLER BEARING

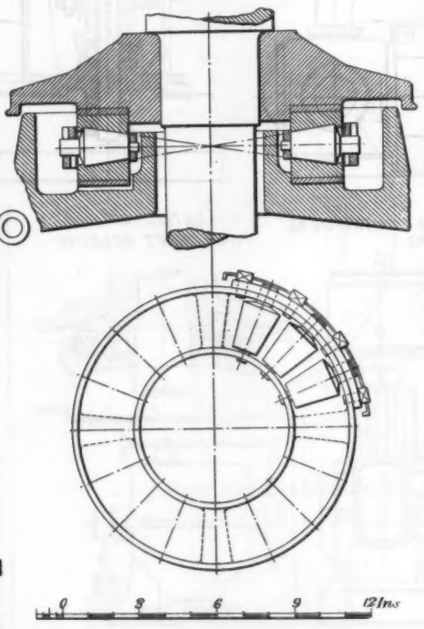



Fig. 14, which is a long shallow box underneath the pontoon bottom into which the bellmouth dips. The bottom plating is pierced with holes leading into the trough, through which the water drains. Even with these devices it is found difficult to get all the water out of the pontoon, for when the water gets low, whirlpools form, and air passes through the pipes into the pumps, tending to destroy the vacuum, and cause the pumps to lose water. A number of remedies have been suggested to overcome this difficulty.

In one case, floating valves were fitted over the holes leading into the troughs. These valves were intended to be sucked down and so close the hole when whirlpools formed. In a second case, dished plates of considerable diameter were fixed over the holes a few inches above the bottom plating to prevent the formation of whirlpools. Graduating the size of the holes proportionally to their distance from the pipe was also tried. These expedients, however, have met with doubtful success, and if it be required completely to drain the pontoon, it is usually necessary to resort to the drainage pumps.

The connection between the bellmouth and the main drain is shown to a larger scale in Fig. 15, the letters corresponding to those in Fig. 1. The direct-lift valve C, operated from the valve or control house, is of the parallel-gate type; the halves of the gate, which are of gun-metal, are pressed on to their seating by a helical spring. Fig. 16 shows the type of expansion joint with its glands, which are introduced in the main drain B to allow for changes in temperature and longitudinal bending. The water travels along the main drain until it reaches the pumps, where it is discharged overboard; details of pumps are shown in Figs. 17, 18 and 23.

The pumps are, as a rule, of the vertical spindle type. They are seated on the main drain, and take water entirely from the under side, discharging directly overboard. Their construction is sufficiently indicated in the figures given. Fig. 17 is of historical interest, and represents an early type of centrifugal pump introduced into a number of early floating docks. Some of these pumps are, however, believed to be doing good work at the present day. The impeller consists of two flat plates of wrought iron, with blades formed of short lengths of channel iron, which also connect the said plates together. A modern pump by Messrs. Gwynnes, Limited, is shown in Fig. 18. Pumps by a Continental maker are illustrated in Fig. 23. The performance curves of a modern pump made by Messrs. W. H. Allen, Son and Co., Limited, are shown in Fig. 19, page 740.

The pump discharge is governed by a screw-down valve operated from the top deck by means of a hand-wheel. An indicator gear is provided to show whether the valve be open or closed. An automatic or flap valve, shown in Fig. 20, is also fitted at the outside of the pump discharge. This valve is opened by the rush of water from the pump, and closes automatically should the pump lose water for any reason. The valve can, however, be lifted from the valve house if desired by means of the chain connection shown.

Similar screw-down valves and flap valves are provided on the inlet branches (E, E, Fig. 1) to the main drain. Through these inlets the water enters which is required for sinking the dock. This water reaches the compartment *via* the main drain and compartment pipes and control during the sinking operation, as in the lift, is maintained by means of the compartment valves C, C. In the case of the inlet valves, however, the flap valve, Fig. 21, is provided with a cage to keep out floating debris, and a pilot valve also to facilitate opening under the external water pressure. This valve is operated from the valve-house by means of the chain indicated.

It has been the practice of the author's firm in the past to make both inlet and discharge bellmouths in the form of a *vena contracta*, Fig. 21. Recently a distinguished firm of pump makers, basing their conclusions on their own and Professor Gibson's experiments,* suggested that the form shown in Fig. 20 was preferable, particularly for the pump discharge. It would appear that from the theoretical point of view the exact shape of the curve does not make much difference, though Fig. 20 is the simpler casting.

The pumps are driven through vertical shafting by engines or motors placed on the top deck of the side wall or on a special engine deck, Fig. 1, provided for them. When steam engines are used, they are usually compound engines of the type shown in Fig. 22, which drawing shows a design of Messrs. Gwynnes, Limited. This type of engine has a vertical shaft and drives direct. The cylinders are horizontal, and at right angles to one another. The steam pressure is usually about 150 lb. per square inch, and the revolutions in the neighbourhood of 350 per minute. Very small engines have one cylinder only, but are otherwise of the same type. In the earlier docks it was usual to have a vertical engine of the ordinary marine type and drive through bevel gear. Fig. 23 shows a modern development. Here a single high-speed vertical engine is employed, driving two pumps through enclosed bevel gear, which have then to be, one right-handed, and the other left-handed, as shown. Clutch gear is arranged so that either pump may be driven separately. The shaft bearings are of the ball type. A similar arrangement with oil engines is quite practicable. Where steam engines are employed, they are usually of the non-condensing type. In large docks, or where fresh water is scarce, condensing engines are fitted.

The boilers employed are either of the usual cylindrical type or water-tube boilers of the Babcock and Wilcox marine type. In small docks, and for the auxiliary machinery, vertical Cochran boilers are used. The boilers like the engines, are preferably placed on the top deck of the side wall in suitable boiler houses, which, for use in the tropics, are made as open as possible.

When electricity is available, it may advisedly be employed instead of steam power. The type of motor used is shown in Fig. 24. The shaft is vertical, and is coupled directly to the vertical shafting which drives the pump. With the early types of centrifugal pumps, series or compound wound motors were used. With the modern centrifugal pump, however, a constant-speed motor is quite practicable, and more recently three-phase and shunt-wound motors have been successfully employed.

Usually the current is supplied through suitable cables from the shore. In some docks, however, the power is generated on board. For example, in the Black Sea Dock, of 30,000 tons lifting power, the three-phase current for the main pumping plant is generated by two turbo-alternators of the A. E. G. Curtis type, each of which has an output of 310 k.v.a. at 525 volts between the phases, 50 cycles, power factor 0·9. Each generator is capable of supplying the current required by five of the ten electric motors driving the main pumps. They run at 3,000 r.p.m., taking steam at a working pressure of 12 atmospheres, supplied by four Scotch marine type boilers, and exhausting into condensers.

In a more recent 50,000-ton design, power was generated in a floating power station moored to the dock and carried on board the dock through suitable cables. This obviates a good deal of congestion on the dock, and reduces the dead load which has to be carried by it.

The engine or motor is connected to the pump by a length of vertical shafting, carried in bearings attached to the hull of the dock. The long bearing in the pump immediately above the impeller is usually lined with lignum vitæ. The remaining bearings are of the ordinary plummer-block type. The whole weight of the vertical shaft and the impeller is carried on a thrust bearing at the engine deck level. The shaft is therefore entirely suspended. Types of this bearing are shown in Figs. 22 and 23, which are of the ball type. Occasionally roller bearings are used, Fig. 25. The coupling between the engine shaft and the vertical shafting is preferably of the flexible type, as shown in Fig. 22. Here the engine-shaft ends in a flange which carries a number of projecting pins on which rubber or leather washers are threaded. These rubber-clad pins work in slots or holes in a corresponding flange keyed and cottered on to the vertical pump shaft, which is thus driven by the pins.

*(To be continued.)*

* "On Flow of Water through Pipes and Passages having Converging or Diverging Boundaries," by Professor A. H. Gibson, D.Sc., Proc. Royal Society, 1909, vol. lxxxiii, page 866.

## EXPLOSION OF A FERTILISER FILTER.

THE very complete system of inspection by the various boiler associations and insurance companies, now so universally adopted throughout the country, coupled with the effective working of the Factory Act and the Boiler Explosions Acts, has led in recent years to a considerable reduction in the number of steam boiler explosions of a serious character. It has, however, resulted in bringing to light many explosions from steam vessels of various types from which hitherto danger had been little recognised. These are now regularly notified to the Board of Trade, and an investigation made by their surveyors is followed by their detailed report. Inasmuch as in many cases persons have been killed or injured by what we may term these "minor" explosions, it is desirable that complete information should be given in order to prevent such occurrences and protect the lives of those in charge of the vessels concerned.

Attention has been directed to this matter by a report which has just been issued by the Board of Trade on a preliminary inquiry made in regard to the explosion of a fertiliser filter which occurred on March 4, at the works of Messrs. Gibbs' Fertilisers Limited, Victoria Docks, London. One man was injured, but not seriously, and he was able to resume work in a few days.

The filter was a cylindrical cast-iron vessel, composed of four parts. The main cylindrical portion was 2 ft. in diameter internally, and $\frac{3}{4}$ in. thick, and this inner cylinder was surrounded by an annular steam jacket space $1\frac{1}{2}$ in. wide, but this steam jacket was not used. An outer cylinder, $\frac{3}{4}$ in. in thickness, completed the casting, which had flanges 1 in. in thickness at the top and at the bottom 2 ft. $8\frac{1}{2}$ in. in diameter, which were provided with bossed parts for the inlet and outlet connections, of $\frac{3}{4}$-in. bore, for steam. The base, which was of dished form, was attached to the main cylinder by fourteen $\frac{3}{4}$-in. bolts, and the outlet branches, to conduct the fluid fertiliser from the filter, were cast in the base. A flanged ring with ribbed recesses for seven hinged $\frac{3}{4}$-in. bolts for holding the cover, was bolted to the upper flange of the main cylinder by fourteen $\frac{3}{4}$-in. bolts, and the cover, which was placed upon the ring, was also dished to a radius of 1 ft. 6 in., and was $\frac{3}{4}$ in. thick at the flanges and $\frac{1}{4}$ in. thick at the crown. The flange of the cover, which was $1\frac{1}{4}$ in. in thickness, was slotted to receive the seven hinged bolts. The length of the cylindrical chambers when assembled was 3 ft. 3 in. Two circular grids were fitted to the inside of the cylinder to retain any insoluble material. The dissolved fertiliser was admitted to the top of the filter by a 3-in. cock from the digester at a pressure of about 50 lb. per square inch, which was sufficient to force it through the filter, and thence into a cylindrical receiver through a 3 in. cock attached to the base of the filter.

The filter was made by Messrs. George Scott and Son, Limited, of Kingsway House, London, in 1920, and was not quite one year old. No repairs had been made to it, and it was not inspected or insured by any society, but was cleaned out under the supervision of the works' manager, Mr. Stoye, once a week.

The cover was burst by the pressure of the fluid passing through the filter; the metal was fractured along a series of lines roughly radiating from the crown to the slotted bolt holes at the circumference.

The probable cause of the failure of the cast-iron cover was the stressing of the material in screwing down the joint. The cover was provided with a recess in the flange, inside the line of the bolts, which held a rubber jointing ring projecting from the underside of the flange. As there was no corresponding ring outside the bolts, there would be a considerable bending stress imposed upon the material when the bolts were hardened down, and as the joint became worn no doubt greater pressure would be applied to make the joint tight. The application of a pressure of about 45 lb. per square inch to the unsupported surface, 2 ft. in diameter, which was already stressed in the manner described, would be sufficient to produce the fractures shown, and this supposition is strengthened by the fact that the lines of fracture, in each case, originated from a bolt at the circumference. All the surfaces of the fractures were clean, the thickness of the metal was fairly uniform, and there were no signs of previous flaws.

In his "general remarks," Mr. McConnell concludes his report to the Board of Trade as follows:

"The installation at Messrs. Gibbs' Fertiliser Company's works, of which the filter formed a part, is engaged in the production of chemical fertilising material from scrap leather. The apparatus consists of two large cast-iron cylinders, called digesters, which are set vertically and which contain about 2 tons of the material to be used. These vessels are in use alternately; the cover is removed from the top and scrap leather put in, water and sulphuric acid is added to complete the charge. The cover is replaced, and steam at 50 lb. pressure is admitted through the base directly upon the contents, which boil for about 1½ hours and dissolve into a heavy viscous fluid. The steam supply is then shut off and the dissolved mass is passed through the filter, which retains upon grids any insoluble matter, and the remaining fluid is discharged into a cylindrical receiver, which delivers it to heated rollers which roll it into a thin hard sheet, which is crushed to powder. Steam is supplied by a Lancashire boiler, 30 ft. long and 7 ft. in diameter, at a pressure of 95 lb. per square inch, which is reduced to 50 lb. per square inch at the digesters by a reducing valve supplied by Dewrance and Co., London. A safety valve loaded to 50 lb. per square inch is also fitted to each digester, and a safety valve loaded to 20 lb. per square inch is provided on the receivers, but it is doubtful if these safety valves would operate at the designed pressure, as, owing to the nature of the fluid they are required to be in contact with, they cannot be kept clean. On the day of the explosion the dissolved fertiliser was being run out of one of the digesters, through the filter and into the receiver; steam had been shut off and the cocks controlling the fluid were opened, but shortly afterwards the cover of the filter was forced upwards, breaking into seven pieces, one of which in descending struck the attendant on the head. He was able to close the cocks, however, and prevent any more serious consequences following from the escape of the boiling fluid. A new cover was obtained, but a steel plate, 1 in. in thickness was adopted in place of the cast-iron previously used, and the filter was tested by hydraulic pressure to 100 lb. per square inch with the new cover in place, before being put into operation.

"The feature in the design of the cover to which the explosion has been attributed is one that has been discarded by engine-makers for a considerable time, as it is well known that the omission of a ring of material outside the bolt circle, especially in the case of cast-iron covers, introduces the danger which in this case has been exemplified by failure."

The following "observations" of Mr. Thomas Carlton, Engineer Surveyor-in-Chief to the Board of Trade, appear at the close of the report:

"The method of jointing employed in this case was no doubt the cause of heavy stresses being imposed on the cover, and it failed under ordinary working conditions. It would also appear from the direction of the fractures that some of the bolts had been more tightly screwed up than the others.

"This method of jointing covers is attended with risk when the material used in the cover is cast-iron, and, as in this case, is of comparative thin section."

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University of London, University College; Goldsmid Engineering Scholarships.—The College Committee have awarded Goldsmid entrance engineering scholarships of the value of 20*l.* each, tenable for three years, to Mr. H. J. Channon, Mr. P. Hall, Mr. H. Kaufmann, on the results of the scholarship examination held in September.

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The Swedish State as an Ironmaster.—The failure of the Porjus Electric Furnace Company (Porjus Smältverk) in Lapland has caused general disappointment in the industrial circles in Sweden, the undertaking being looked upon almost in the light of a national concern. The conditions were considered favourable, with abundance of iron ore at hand and a sufficiency of electric energy available from the Porjus State hydro-electric power station. However, the concern was unable to carry on, and it has now been proposed that the Swedish State should step in, either to take over and work the undertaking, or, in any case, find sufficient money to establish and keep the concern going.

## AVOIDABLE WASTE IN LOCOMOTIVE OPERATION AS AFFECTED BY DESIGN.*

By James Partington, Estimating Engineer, American Locomotive Company, New York, N.Y.

It seems advisable to consider this subject from the constructive standpoint of indicating what constitutes good design as demonstrated by locomotives in actual service, rather than to attempt to point out the defects in locomotives which do not show maximum efficiency. If any power plant or engine is not properly proportioned for the work it has to do, the most expert skill in operation can reduce only in part the waste resulting from having such equipment in service.

First, considering the design of steam locomotives from the standpoint of new equipment, when a railroad company is in the market for new locomotives its requirements may be met sometimes by duplicating locomotives in service on its road, but adding newly developed attachments which make for increased efficiency and economy. More frequently, however, it will be found that increased traffic, change from wooden to steel cars, improvement in track, road-bed and bridges, &c., will justify and make advisable the adoption of locomotives of a larger and more powerful type.

Then careful consideration must be given to service requirements—maximum loads to be hauled, capacity of cars, approximate proportion of loaded to empty cars per train, grades, curves, running time over divisions, maximum allowable load per axle, location of coal chutes and water tanks, clearances, conditions under which trains must be started, and any other special requirements of the service. Having determined the draw-bar pull necessary, it remains to design a locomotive that will have the following efficiency requirements:—

(1) A draw-bar horse-power for the minimum amount of fuel.

(2) A draw-bar horse-power for the minimum amount of weight of locomotive and tender.

(3) A draw-bar horse-power for the minimum cost of repairs.

*Fuel Economy.*—As standard practice in modern locomotives, a sectional brick arch in the fire-box and a fire-tube superheater should be applied as a means of saving fuel in any class of service. A sectional brick arch is low in first cost, easily applied and easily renewed. It usually accomplishes a fuel saving of from 10 per cent. to 12 per cent. in coal-burning engines, and about 5 per cent. in oil-burning engines.

The very general use of superheaters has gradually brought about improved conditions of cylinder lubrication, which now make it possible and desirable for the greatest economy to use a high degree of superheat, 250 deg. to 300 deg. now being considered the best practice. A saving of 25 per cent. to 30 per cent. can be obtained.

The use of feed-water heaters will further conserve fuel, and these are now in general use in Continental Europe, and are gradually being applied to locomotives in the United States. The saving that can be realised is as much as 12 per cent. The initial cost is considerable, but the effect of the feed-water heater in operation, aside from fuel economy, will be to help reduce other boiler-maintenance charges.

The general proportions of the boiler should also receive careful consideration. For the best results with bituminous coal, the length of the boiler tubes should be approximately within the following limits:—

| Size of Tube. In. | | Distance Over Tube Sheet. |
|---|---|---|
| 2 | ... | 18 ft. 0 in. to 19 ft. 6 in. |
| 2½ | ... | 22 ft. 6 in. to 24 ft. 6 in. |
| 2¼ | ... | 28 ft. 0 in. to 30 ft. 0 in. |

For many designs of locomotives, a combustion chamber can be provided, and this will help further in the economical production of steam. A generous steam space should be provided, and the throttle designed and located to secure dry steam. The evaporative capacity of the boiler should be as nearly 100 per cent. of the maximum steam requirements of the cylinders as the type of locomotive will permit. Based on 100 per cent. boiler, the grate area should be sufficient to prevent the maximum coal consumption per square foot of grate per hour from exceeding, for bituminous coal, 120 lb., and for anthracite coal, 55 lb. to 70 lb., depending on size.

When the total coal consumption exceeds 6,000 lb. per hour, it is generally necessary to apply an automatic stoker. These have now been so adapted to locomotive requirements that a properly designed stoker will show economy over hand firing, aside from the necessity of its use, on account of the coal consumption being greater than the physical capacity of one fireman if the boiler were hand-fired. The arrangement of deflector and netting in the smoke-box should be carefully adapted to the fuel and combustion conditions, to provide minimum fuel waste and minimum back pressure in the cylinder exhaust passage with proper provision against fire hazards which might obtain by the throwing of sparks.

The boiler being designed to produce steam at a minimum cost, it is now necessary to design the engine to use this steam with maximum economy. The cylinder proportions and diameter of the drivers should be such as will develop maximum horse-power at the ruling speeds for train movements. The greatest horse-power of locomotive cylinders will usually be developed within a piston speed ranging from 700 ft. to 1,000 ft. per minute. Therefore, if other traffic conditions will permit, the operation of trains within these limits should show the greatest operating economy.

*Minimum Weight of Motive Power Equipment.*—The weight on the locomotive drivers gives engine friction, independent of other factors, of 22 lb. per ton. The desirability of avoiding excess weight on the drivers from this standpoint alone is therefore readily apparent. When the type of engine will permit, this weight should not exceed what is necessary to give a satisfactory factor of adhesion; that is usually 4½ times the maximum tractive power. All weight in excess of this and all other excess weight and excess tender weight should be eliminated, as far as this can be done without detriment to the design of engine and tender. This applies with particular force to the machinery parts of the engine, especially those parts which affect the counterbalance. All saving in weight in these parts usually produces a similar saving in counter balance weights and a reduction in the dynamic augment, which is very desirable from the standpoint of track and road-bed maintenance.

The use of special materials to keep down weight is often amply justified if repair parts can be obtained promptly when required. This, in the past, has often been the cause of delay, but it can be guarded against by carrying a few spare parts in stock ready for renewals. High-tensile alloy steel can frequently be used to advantage for driving axles, crank pins, main and side rods, piston rods, &c. Occasional steep grades or hard starting conditions at stations may cut down the hauling capacity of locomotives over a division to a serious extent. In such cases, the utilisation of the weight on trailer trucks for additional tractive power in starting and at slow speeds may increase the capacity of the locomotive from 10 per cent. to 25 per cent., depending on the number of driving wheels and working pressure. It has been demonstrated that a separate steam engine or booster geared to the trailing axle will give this additional traction, and that it can be cut in or cut out very satisfactorily as occasion may require.

This is an item in economical operation worthy of consideration where hauling capacity is restricted by such limitations, and the use of an independent booster may often permit the satisfactory operation of considerably lighter locomotives for service of this character. Within the limits of this paper, only the major features of design can be outlined briefly, and only such devices as have been carefully tried out and are in successful operation are cited. The writer believes the savings mentioned are well within what may be obtained in practice. Many other improvements promising further economy in the generation and use of power in the steam locomotives are contemplated, and in the experimental stage, but these do not properly come under the scope of our subject as here treated.

*Cost of Repairs.*—It has been pointed out that locomotives and tenders should be designed to produce the required draw-bar horse-power with as little excess weight as possible. In this connection, however, due consideration must be given to the question of repairs.

The design of boilers from the standpoint of weight is practically fixed by existing boiler regulations, which provide that locomotive boilers must be operated with a factor of safety of not less than four. Practically all boilers at the present time are designed with a factor of safety of 4½, which leaves a comfortable margin between this and the minimum allowable operating factor. The maximum stresses in other parts of the locomotive must also be carefully considered, and the parts must be designed to keep these stresses within limits which will eliminate costly failures in service.

Aside from the consideration of stresses, much repair cost can be avoided by adopting designs which reduce the number of parts, as far as reasonably may be, especially where these parts must have bolted connections. Here, however, care must be taken to avoid construction which cannot readily be removed for repairs or renewals, or repaired in place with reasonable facility. Many roads to-day are giving a great deal of thought to locomotive design along these lines, having especially in mind the desirability of making the engine parts:

Accessible for oiling and inspection.
Easily removable with proper shop facilities.
Of the minimum number of pieces.
Interchangeable with equipment now in service.

The repair shop facilities must, of course, be kept abreast of the requirements; *i.e.*, as new and larger locomotives are put in service, turntables, cranes, machine tools, &c., must be of sufficient capacity to handle the larger equipment economically. The repairs of locomotives can often be facilitated, and the necessary shop equipment kept down to the minimum by securing from the locomotive builder many parts which he is able to turn out more accurately and more economically than the average railroad shop would be equipped to do. Such parts include:—

Flanged sheets for boiler repairs.
Flexible and ordinary staybolts.
Finished bolts and nuts.
Drop-forgings.
Packing rings for pistons and piston valves.
Special equipment which required special tools for its production.

Without attempting to pursue further the design of new locomotives it may be remarked that a study of the special conditions of individual railroads is necessary to secure equipment best suited to the needs of each.

*Old Motive Power Equipment.*—Much waste in locomotive operation can be avoided by making a careful survey of present motive power equipment, which is not giving as economical or efficient service as could be obtained if the engines were modernised. This applies particularly to locomotives where the service con-

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* Paper to be read at the meeting of the Railroad Division of the American Society of Mechanical Engineers, December 9, 1921.

ditions demand more power than the present equipment can economically produce. All the suggestions made in regard to the design of new equipment are applicable to a greater or less degree to old equipment, providing the will warrant the additional cost of changes and betterments necessary to convert it into up-to-date power. This can be decided by taking the number of years the engines will be retained in service and the increased net service, as against the cost of contemplated changes in the old equipment. If these comparisons show a saving in favour of modernising the old equipment or the purchase of new equipment, every month that the engines

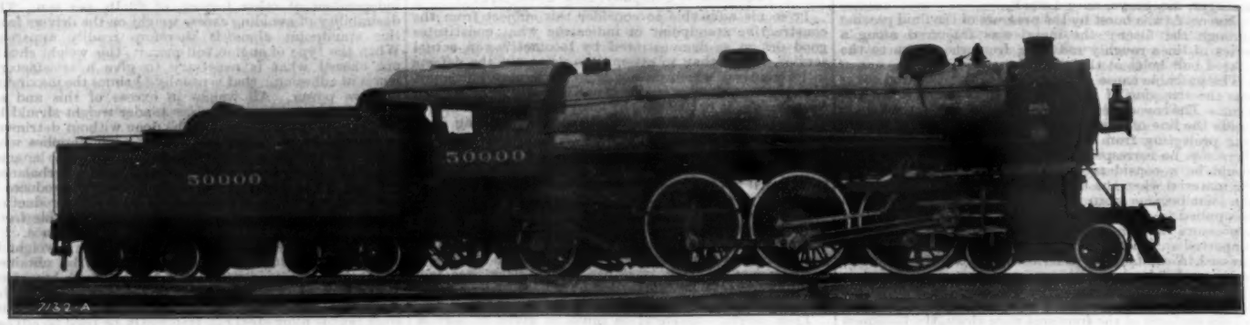



FIG. 1. ENGINE NO. 50000 OF THE AMERICAN LOCOMOTIVE COMPANY; IN SERVICE ON THE ERIE RAILROAD.

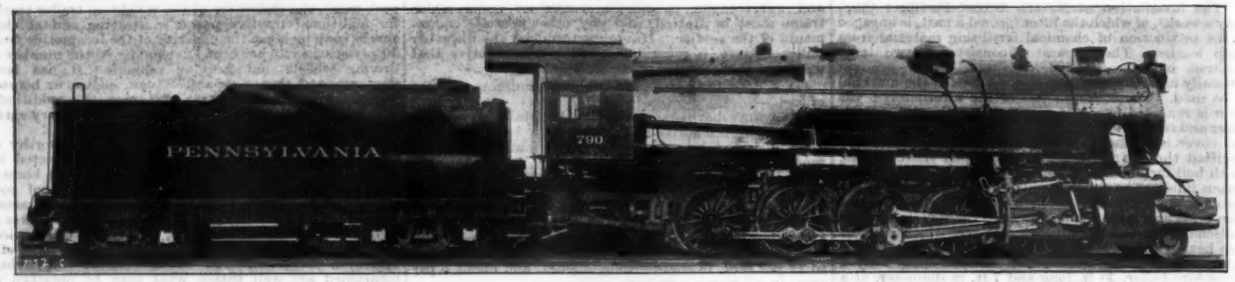



FIG. 2. ENGINE NO. 790, OF THE PENNSYLVANIA RAILROAD; CLASS IIs.

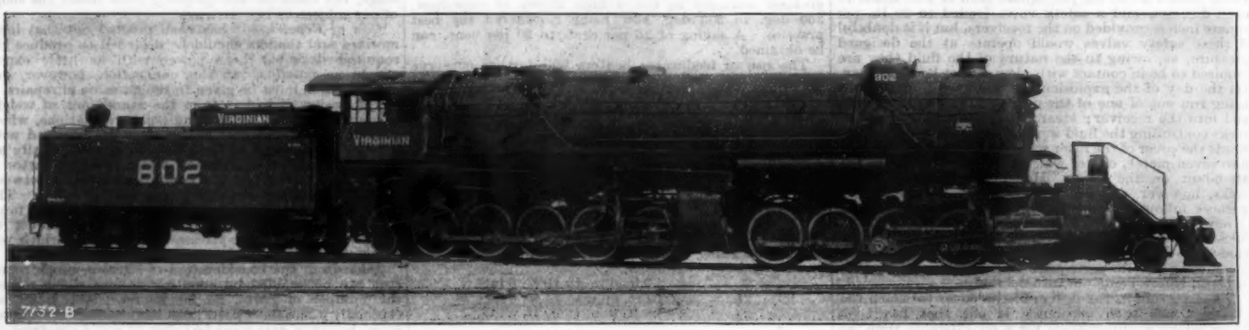



FIG. 3. ENGINE NO. 802, OF THE VIRGINIAN RAILROAD; CONSTRUCTED BY THE AMERICAN LOCOMOTIVE COMPANY.

## TABLE I.—LARGE PACIFIC TYPE LOCOMOTIVES NOW IN OPERATION IN THE UNITED STATES.

THE COLUMN PRECEDING THE COLUMN OF AVERAGES COVERS ENGINE NO. 50000.

| | | | | | | | | | | | | | Average. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cylinder | 27″×28″ | 25″×28″ | 25″×30″ | 27″×28″ | 26″×28″ | 26″×28″ | 23½″×26″ | 26″×28″ | 25″×28″ | 25″×28″ | 25″×28″ | 27″×28″ | 25·6″×28″ |
| Drivers—diameter in. | 80″ | 79″ | 75″ | 77″ | 79″ | 75″ | 79″ | 75″ | 77″ | 80″ | 75″ | 79″ | 77·5″ |
| Boiler—diameter | 78½″ | 76⅝″ | 79⅜″ | 75 15/16″ | 78″ | 78 7/16″ | 70⅜″ | 76″ | 74″ | 72″ | 69″ | 76⅝″ | — |
| Pressure lb. | 205 | 210 | 200 | 185 | 210 | 200 | 200 | 190 | 200 | 200 | 185 | 185 | 197·5 |
| Fire-box length | 126″ | 126″ | 111⅛″ | 114 1/16″ | 126½″ | 114⅛″ | 108¼″ | 110″ | 120⅛″ | 126¼″ | 108⅛″ | 114⅛″ | — |
| Fire-box width | 80″ | 108¼″ | 84⅜″ | 84″ | 108½″ | 84⅛″ | 75½″ | 72″ | 84″ | 108½″ | 70½″ | 75½″ | — |
| Tube length | 19′ | 17′ 3″ | 18′ 6″ | 22′ | 19′ | 20′ 6″ | 21′ 6″ | 20′ | 22′ | 19′ | 20′ | 22′ | — |
| Wheel base driving | 13′ 10″ | 14′ | 13′ 2″ | 14′ | 13′ 10″ | 13′ | 14′ | 13′ | 13′ 4″ | 13′ 10″ | 13′ 6″ | 14′ | — |
| Wheel base engine | 36′ 6″ | 36′ | 34′ 9″ | 36′ 2″ | 35′ 8″ | 34′ 11″ | 36′ 6″ | 34′ 4″ | 35′ 8″ | 35′ 7″ | 34′ 9″ | 35′ 7″ | — |
| Weight on drivers lb. | 201,800 | 192,500 | 181,500 | 178,000 | 181,400 | 194,000 | 184,500 | 169,500 | 165,000 | 176,900 | 168,500 | 172,500 | 180,500 |
| Weight of engine lb. | 308,900 | 302,000 | 299,000 | 295,000 | 291,400 | 287,000 | 282,000 | 280,000 | 279,500 | 273,600 | 269,000 | 269,000 | 286,400 |
| Heating surface tubes and flues sq. ft. | 3,746·8 | 2,830 | 3,232 | 3,534·7 | 3,454 | 3,939 | 3,193 | 3,380 | 3,720·9 | 2,644 | 2,970 | 3,808 | — |
| Heating surface, fire-box sq. ft. | 288·6 | 351·0 | 297·6 | 239·8 | 303·0 | 259·6 | 231·0 | 240·0 | 266·4 | 282·0 | 230·0 | 248·0 | — |
| Heating surface, total sq. ft. | 4,035·4 | 3,181·0 | 3,529·6 | 3,774·5 | 3,757·0 | 4,198·6 | 3,424·0 | 3,620·0 | 3,987·3 | 2,926·0 | 3,200·0 | 4,056·0 | 3,640·8 |
| Superheating surface sq. ft. | 1,154·0 | 645·0 | 803·0 | 962·0 | 816·0 | 970·0 | 838·0 | 830·0 | 783·5 | 652·0 | 778·0 | 897·0 | — |
| Grate area sq. ft. | 70·0 | 95·0 | 65·0 | 66·5 | 94·8 | 67·0 | 56·5 | 55·0 | 70·4 | 94·5 | 52·7 | 59·8 | 61·6* / 70·6 |
| Tractive power lb. | 41,845 | 39,500 | 42,600 | 41,700 | 42,770 | 42,900 | 30,900 | 40,700 | 38,600 | 37,200 | 36,700 | 40,600 | 39,670 |
| Cylinder horse-power h.p. | 2,090 | 2,365 | 2,252 | 2,427 | 2,556 | 2,434 | 1,990 | 2,312 | 2,252 | 2,252 | 2,083 | 2,427 | 2,336 |
| Boiler horse-power h.p. | 2,467 | 2,244 | 2,282 | 2,104 | 2,311 | 2,398 | 1,958 | 2,112 | 2,257 | 1,950 | 1,869 | 2,235 | 2,186 |
| Weight per cylinder h.p. lb. | 114·8 | 127·7 | 132·8 | 121·5 | 114·0 | 117·9 | 141·7 | 121·1 | 124·1 | 121·5 | 129·1 | 110·8 | 122·8 |
| Weight per boiler h.p. lb. | 125·2 | 134·6 | 131·4 | 140·2 | 126·1 | 119·7 | 144·0 | 132·6 | 123·3 | 140·3 | 143·9 | 120·3 | 131·8 |
| Boiler percentage | 91·7 | 95·0 | 101·0 | 86·7 | 90·5 | 98·5 | 98·2 | 91·5 | 100·5 | 86·8 | 90·0 | 92·0 | 93·5 |

Figure marked * is an average of the soft coal burning engines only. The figure 70·6 is the average for all the engines, including the hard coal burners.

old equipment is not meeting the demands of the service from a power standpoint, or is not furnishing this power economically.

In making a survey of this character care should be taken to determine accurately whether the old equipment return or saving for this period as against the cost involved for changes, interest on the additional investment, increased maintenance, &c. A comparison should also be made with the results that could be realised by the purchase of new equipment best adapted for the are kept in service without doing this will result in a loss that is not recoverable. A few concrete examples of what has been accomplished in service by locomotives designed to yield maximum efficiency may be of advantage.

Notable designs, for which data is available, are as follows :—

Pacific type passenger locomotive No. 50000, built by the American Locomotive Company (Fig. 1, on the opposite page).
Decapod type freight locomotive, Class Ils built by the Pennsylvania Railroad Company (Fig. 2).
Heavy Mallet special service locomotive, built for the Virginian Railway by the American Locomotive Company (Fig. 3).

*American Locomotive Company Engine No.* 50000.—Locomotive No. 50000 was built by the American Locomotive Company in 1910. It was designed and constructed at the builders' expense to demonstrate the maximum tractive power with adequate boiler capacity that could be obtained while keeping the adhesive weight below 60,000 lb. per driving axle. Untrammelled by any outside specifications or the necessity of conforming to any railroad's existing standards, the builders had a free hand to embody in this design their ideas of the best engineering practice. To accomplish the purpose of the design—the maximum capacity per pound of weight—the largest boiler capacity within the predetermined wheel loads was the essential feature. This end was obtained by eliminating every pound of weight in all the parts that was not necessary to strength and durability, utilising the weight thus saved to provide a larger boiler, and by increasing the capacity of the boiler thus secured by combining in one design the most approved fuel-saving devices to obtain the utmost economy in boiler and cylinder performance. Many of the large Pacific type locomotives with drivers 75 in. in diameter and over in operation to-day greatly exceed locomotive No. 50000 in total weight.

An average of all the important engines of this type, including locomotive No. 50000, shows approximately 1,000 lb. less tractive power with an increase of 17,400 lb. in weight with the very slight advantage of only 1½ per cent. in boiler capacity. (See Table I on the opposite page).

Locomotive No. 50000 delivers one cylinder per horse-power for every 110·8 lb. of weight and 1 boiler horse-power for every 120·3 lb. of weight.

In actual tests it developed :—

An average rate of 2·21 lb. of coal per indicated horse-power hour.
A low rate on one test of 2·12 lb. of coal per indicated horse-power hour.
An average rate of 16·85 lb. of steam per indicated horse-power hour.
A low rate on one test of 16·5 lb. of steam per indicated horse-power hour.
A maximum indicated horse power of 2,216, or 1 h.p. for every 121·4 lb. of weight.

The thought occurred that possibly No. 50000 was built too light, and that later on in order to keep the engine in service many of the parts might require strengthening.

Locomotive No. 50000 was purchased by the Erie Railroad and numbered 2509; Mr. William Schlafge, mechanical manager of the Erie, states that since the locomotive was received it has been necessary to make very few changes. The guide yoke was reinforced on account of working. Guide yoke blocks were also made solid on the guide yokes. The trailer spring sliding block was changed to the same type as used on their K-4 Pacific type locomotives. No other changes or alterations have been made. Yet from the time this locomotive was placed in service on the Erie Railroad up to March 1, 1920 it had made a total mileage of 351,800.

Ten years of service coupled with 350,000 miles of running demonstrate the strength of the design, and the figures given indicate remarkable performance.

*Pennsylvania Railroad Class* IIs.—While the design of engine "50000" represents the best practice of the present day as measured by the economical operation of passenger locomotives, the development of heavy freight power involves the consideration of other factors that materially affect the design. In 1915 the Pennsylvania Railroad found that for the economical operation of their line a tractive power about 25 per cent, in excess of the "Mikados" then in use was desirable. In working on the design for such an engine, an attempt was made to obtain better economy in performance by a radical departure in cylinder proportions. The accepted practice in proportioning cylinders is to arrange for a cut-off of nearly 90 per cent. of the stroke, so that the starting torque may be as uniform as possible.

As the adhesive weight limits the cylinder diameter if excessive slipping is to be avoided it is obvious that on long grades, where the maximum tractive effort is required, the long cut-offs use steam in a most uneconomical manner. As the Pennsylvania Railroad, has several such long grades on its line, the new design adopted involved a limitation of the cut-off to about 50 per cent. in place of 90 per cent., and an increase in the cylinder diameter to give sufficient torque at this cut-off to fully utilise the adhesive weight. The expected increase in economy of coal and water due to the shorter cut-off has been fully realised.

Not only has the engine shown remarkable efficiency, but the economy under wide range of load is especially remarkable. We are fortunate in having available a very complete test of this engine, made on the testing plant at Altoona. (Bulletin 31, P.R.R. Testing Plant, 1919, copyrighted.) This test shows a water rate of 15·4 lb. per indicated horse-power hour with a total indicated horse power of 3,080 at 40 per cent. cut-off and a coal consumption of 2·9. The lowest coal consumption recorded is 2 lb. per indicated horse-power, obtained at an output of 1,777 i.h.p. and a cut-off of 30 per cent. The thermal efficiency of the locomotive is also high and well sustained over a large range, a maximum of 8·1 being attained at an output of 1,777 i.h.p., and the range being from 6·1 per cent. at 776 i.h.p. to 5·3 per cent. at 3,486 i.h.p. with an average of over 7 per cent. for the usual operating conditions.

The highest draw-bar pull recorded in these tests is 76,211 lb. at a speed of 7·4 m.p.h., but in road service a pull of 80,640 has been recorded at 7·2 m.p.h. The indicated tractive effort plotted from a card taken at 7·4 m.p.h. at 55 per cent. cut-off is slightly over 90,000. This design gives a calculated figure of 88·9 lb. per cylinder horse-power, the lowest on record. During the tests an indicated horse-power of 3,486 was developed, giving a weight of 106·2 lb. per horse-power. The weight per boiler horse-power does not compare as favourably, however, as it is 145·4. The Belpaire firebox contributes materially to this excess.

TABLE II.—*Modern Maximum Efficiency Locomotives.*

| | No. 50,000 Erie | Pennsylvania | Virginian |
|---|---|---|---|
| Type | 4-6-2 | 2-10-0 | 2-10-10-2 |
| Fuel | Bituminous coal | Bituminous coal | Bituminous coal |
| Boiler, type | Conical connection | Conical connection | Extended wagon top |
| Boiler, diameter | 76½"-87" | 87"-90¼" | 105½"-118½" |
| Weight on drivers lb. | 172,500 | 342,050 | 617,000 |
| Weight on truck lb. | 49,000 | 29,750 | 32,000 |
| Weight on trailer lb. | 47,000 | — | 35,000 |
| Weight—total lb. | 269,000 | 371,800 | 684,000 |
| Driving wheel diameter | 79" | 62" | 56" |
| Cylinders | 27"×28" | 30½"×32" | 30" & 46"×32" |
| Boiler pressure lb. | 185 | 250 | 215 |
| Tractive power lb. | 40,600 | 90,000 | 147,200 |
| Factor of adhesion | 4·25 | 3·80 | 4·08 |
| Cylinder horse-power h.p. | 2,427 | 4,182 | 5,040 |
| Grate, length and width | 114"×75½" | 126"×80" | 144"×108½" |
| Grate area sq. ft. | 59·7 | 70·01 | 108·7 |
| Tubes, number | 207 | 244 | 381 |
| Tubes, length | 22' | 19' 1" | 25' |
| Tubes, spacing | 2" | 2" | 2" |
| Tubes, thickness | 11 B.W.G. | 0·128" | 11 B.W.G. |
| Tubes, diameter | 2½" | 2½" | 2½" |
| Flues, number | 36 | 48 | 70 |
| Flues, diameter | 5½" | 5½" | 5½" |
| Flues, thickness | ¼" | 0·18" | 9 B.W.G. |
| Combustion chamber, length | None | 42" | 36" |
| Brick arch | Security | Security | Gaines |
| Heating surface, fire-box sq. ft. | 248 | 290 | 532 |
| Heating surface tubes, water side sq. ft. | 2,672 | 2,731 | 5,592 |
| Heating surface flues, water side sq. ft. | 1,136 | 1,313 | 2,511 |
| Heating surface—total sq. ft. | 4,056 | 4,334 | 8,635 |
| Boiler horse-power h.p. | 2,250 | 2,553 | 4,800 |
| Steam rate, calculated lb. per h.p.-hour | 20·8 | 20·8 | 19·7 |
| Coal rate, calculated lb. per h.p.-hour | 3·25 | 3·25 | 3·1 |
| Superheater, number of units | 35 | 42 | 70 |
| Superheater diameter | 1¼" | 1¼" | 1¼" |
| Superheater heating surface sq. ft. | 879 | 1,418 | 2,120 |
| Tender weight, in running order lb. | 161,500 | 182,000 | 214,300 |
| Tender capacity, coal tons | 14 | 17½ | 12 |
| Tender capacity, water galls. | 8,000 | 9,000 | 13,000 |
| Weight of locomotive in lb. per cylinder h.p. | 110·6 | 88·9 | 135·7 |
| Weight of locomotive in lb. per boiler h.p. | 119·6 | 145·4 | 142·5 |
| Best actual performance— | | | |
| Steam rate, lb. per h.p.-hour | 16·5 | 15·4 | — |
| Coal rate, lb. per h.p.-hour | 2·12 | 2·0 | — |

*Virginian 2-10-10-2 Type Locomotives.*—The large 2-10-10-2 Mallet engines for the Virginian Railway were designed to meet their unique conditions. This road was built as an outlet to certain bituminous coalfields of West Virginia. Practically the entire revenue business is confined to hauling coal to the shipping docks at Sewall's Point, the west-bound revenue freight being negligible in amount, as only one town of any importance, Roanoke, is located on the line. As the development of the coalfields proceeded, the tonnage to be handled increased rapidly, rising from 2,141,009 in 1911 to 7,621,555 in 1920, and in order to handle the business at a profit the maximum attainable capacity in motive power was demanded. Having fixed on 100 cars as the maximum number that could safely be handled in a single train, the car capacity increased to 120 tons, and it was estimated that a locomotive of 147,000 tractive power would be needed to haul the train from Princeton to tidewater, a helper being used for a grade of 0·6 per cent., 10 miles long, over the Alleghenies. The 2-10-10-2 Mallets were designed to meet these conditions and their operation has been very successful. They have handled trains of 16,000 tons on a 0·2 per cent. grade with the lowest consumption of coal per ton-mile ever recorded. Unfortunately, accurate tests of coal and water per dynamometer horse-power are not available owing to the fact that there is no dynamometer of adequate capacity to be had at present. However, on May 25, a train of 15,725 tons behind the tender was hauled from Princeton to Roanoke at a rate of 26·9 lb. of coal per 1,000 ton-miles, and on May 27 a 75-car train of 12,070 tons showed the same figure for coal per 1,000 ton-miles.

One of these engines has hauled a train of 110 cars weighing 17,250 tons from Victoria to Sewall's Point, which is believed to be the heaviest train ever handled by one engine. The ruling adverse grade was 0·2 per cent. The principal dimensions of the three locomotives cited and a comparison of the horse-power characteristics —calculated by the American Locomotive Company's method—are embodied in Table II above.

## CATALOGUES.

*Switch Gear.*—Messrs. A. Reyrolle and Co., Limited, Hebburn-on-Tyne, send a copy of a souvenir publication containing interesting illustrations of their works and products.

*Fencing.*—The Darlington Fencing Company, Limited, 5, Lloyds-avenue, London, E.C. 3, send a list of various kinds of wire fencing with posts, gates, erecting tools and materials.

*Saw Mills.*—Lists of plant for wood-sawing mills, complete with motor, transmission and machines, are given in a catalogue received from Mr. John T. Pickles Hebden Bridge.

*Pyrometers.*—An explanatory pamphlet of 40 pages relating to pyrometers, has been issued in catalogue form by the Foster Instrument Company, Letchworth, Herts. The information given is very clear and complete.

*Electric Light Fittings.*—An extensive range of fittings made in solid brass and especially suitable for factories, docks and ships is described in a catalogue received from the Engineering and Lighting Equipment Company, Limited, St. Albans, Herts.

*Vanadium.*—A great deal of information about vanadium is given in a 50-page quarto pamphlet issued by the Vanadium Corporation, 120, Broadway, New York, U.S.A., and forwarded to us from their London Office, 64, Victoria- street, S.W. 1.

*Power Transmission.*—A catalogue issued by Messrs. John Jardine, Limited, Deering-street, Nottingham, gives full particulars and prices of a wide range of shafting, bearings, pulleys, gear wheels and other accessories for power transmission. This publication will be very useful to millwrights and engineers generally.

*Oil Well Plant.*—A new edition of their catalogue of engines and boilers specially suitable for drilling oil wells, pumping and other oilfield work, has been issued by Messrs. Ruston and Hornsby, Limited, Lincoln. It includes lists of both oil and steam engines and also of steam boilers of the horizontal and vertical types.

*Tyre Presses.*—Hydraulic and screw presses for fixing and removing solid rubber vehicle tyres are the subject of a special catalogue to hand from Messrs. Hollings and Guest, Limited, Thimble Mill-lane, Birmingham. A second catalogue contains illustrated instructions for laying the foundations for these presses and erecting them.

*Acetylene Lighting.*—Lamps, generators, brackets and all accessories necessary for motor car and vehicle lighting by acetylene gas, and including special outfits intended for use in case of failure of the electric lighting equipment, are illustrated and fully explained in a catalogue received from Messrs. Allen-Liversidge, Limited, 106, Victoria-street, London, S.W. 1.

*Grinding Wheels.*—The catalogues of Norton grinding wheels issued by Messrs. Charles Churchill and Co. Limited, 9, Leonard-street, Finsbury, London, E.C. 2, deals with a remarkably wide range of shapes made up from various sizes of grit and various tenacities of bonding material, and also gives useful directions for selecting and mounting these wheels. Special lists of wheels for each of the well-known makes of grinding machines are included.

*Shipbuilding.*—We have received two very interesting publications from the Chantier et Ateliers de St. Nazaire, 6, Rue Auber, Paris. One of these is a fine album of views of the works, workshops and building yards of the Penhoët Shipbuilding plant, including many illustrations of the famous ships produced by the firm. The other gives an illustrated and detailed description of the new French liner Paris, of 34,500 tons gross and 22·5 knots speed. We dealt with this vessel very fully in our issues of July 15 and 29 and August 12 last, on pages 96, 181 and 246.

*Radial Drilling Machine.*—A design of radial drilling machine is described and illustrated in a catalogue which we have received from Messrs. Alfred Herbert Limited, Coventry. It is driven by an electric motor which is placed on an extension from the radial arm boss so that it balances the weight of the arm and drilling saddle. All the speed, feed, elevating and reversing gears are operated from the saddle, and the safety locks necessary on this type of machine are provided. The machine drills up to 2½ in. in cast iron or 2¼ in. in steel and has sixteen drilling speeds and six feeds.

SILUMIN, AN ALUMINIUM-SILICON ALLOY.—The alloy of silicon and aluminium which was shown at the Berlin Automobile Exhibition of last September is said to consist essentially of aluminium with about 12 per cent. of silicon. The specific gravity ranges from 2·5 to 2·65. The tensile strength is 20 kg. per square millimetre (12·7 tons per square inch).

BRITISH TRADE WITH FRANCE.—In order to assist in the stimulation of British trade with France, the British Chamber of Commerce in Paris is preparing a new and revised edition of its Franco-British Trade Index. The total cost of this, including its distribution amongst French buyers, will be met from the funds of the Chamber, the only stipulation being that the firms appearing therein shall have shown their interest in British trade in France by becoming members of the Chamber. The Chamber entirely depends on the members' subscriptions to carry on its valuable work. Forms of application for membership and forms of insertions for the Trade Index, may be obtained from the Secretary of the Chamber of Commerce, 6, Rue Halévy, Paris.

# "ENGINEERING" ILLUSTRATED PATENT RECORD.

## SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

*The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.*

*Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.*

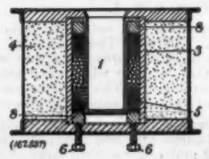
*Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C., at the uniform price of* 1*s.*

*The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.*

*Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.*

### ELECTRICAL APPARATUS.

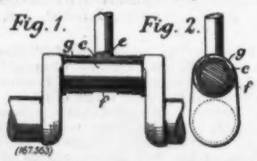
**167,537. A. Imbery, Halifax. Electric Resistance Furnaces.** (2 *Figs.*) April 30, 1920.—This invention has for its chief object to enable the electrical resistance of the heating circuit to be readily adjusted to meet any particular condition of heating or temperature. According to this invention, a resistance element composed of spheres or ovoids of graphite or carbon is arranged between two annular terminal plates which are provided with means for regulating the pressure on the spheres



or ovoids located between them. 1 indicates the crucible fixed between the two annular graphite terminal plates 8. Surrounding the crucible and the terminal plates 8 is a refractory cylinder 3, and surrounding the latter is a packing of refractory material 4. Between the terminal plates 8, the space between the external wall of the crucible 1 and the refractory cylinder 3, is filled with spheres 5 or ovoids of graphite of varying diameter. The pressure upon the spheres is regulated by means of the set-screws 6. (*Sealed.*)

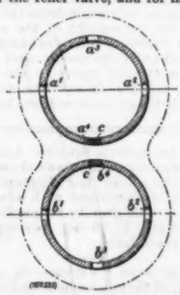
### GAS ENGINES, PRODUCERS, HOLDERS, &c.

**167,563. R. W. Wilson, Newcastle-on-Tyne. Securing Connecting Rods.** (4 *Figs.*) May 7, 1920.—Means for securing connecting rods to crank pins, according to this invention, comprise a coiled spring *g* which is caused to encircle the big end bearing *e* and the crank-pin *c*, and is prevented, when in position from having endwise motion on the crank-pin. A sleeve member *f*



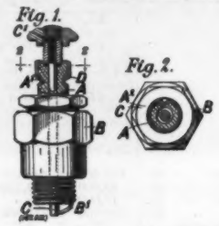

is interposed between the coiled spring *g* and the big-end bearing *e*. The sleeve member is composed of segments or two half-sleeves, the longitudinal edges of the segments or half-sleeves meeting so that the contraction of the spring comes upon the sleeve member and cannot have the effect of binding the big-end bearing on to the crank-pin. (*Sealed.*)

**167,525, Cammell Laird and Co., Limited, Birkenhead, Sir G. J. Carter, K.B.E., Higher Bebington, and L. G. McFarlane, Liverpool. Internal-Combustion Engines.** (1 *Fig.*) April 6, 1920.—In the cylinders or cylinder liners of the Fullagar or opposed piston type internal-combustion engine, it is necessary that the associated pairs of cylinder units should be disposed so that their axes are as close together as possible, in order that the rods connecting the opposite pairs of pistons should have a minimum of obliquity, and in such engines the liner has to be pierced at the central zone, which lies between the pistons at their point of nearest approach, with the necessary openings for the admission of fuel, for the admission of starting air, for the relief valve, and for indicating purposes,



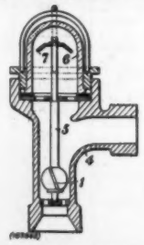
but the valves associated with these openings cannot be located between an associated pair of cylinders. In engines of moderate size, the number of these openings is reduced to two, but as the size of the engine increases, it becomes necessary to increase the number of openings to three, viz.: Two $a^1$, $a^2$, $b^1$, $b^2$, for fuel injection arranged at opposite ends of a diameter disposed transversely to the medial plane of the engine, and the third $a^3$, $b^3$, at right angles to these to take the starting air valve, the relief valve and the indicator connection. The holes thus pierced in the cylinder liner do not provide a cross-section at this zone symmetrical about any diameter, which is a condition necessary to prevent fracture by the stresses induced in this type of engine; and, according to the present invention, this symmetrical arrangement is produced by drilling a fourth opening $a^4$, $b^4$, opposite to the opening $a^3$, $b^3$, the four openings being of equal diameter and uniformly spaced round the circumference of the liner. It is not possible, owing to the proximity of the associated cylinder of the pair, to make use of the fourth opening and this opening is accordingly plugged up. (*Accepted August* 24, 1921.)

**167,552. W. R. Marshall, Camberwell. Sparking Plugs.** (3 *Figs.*) May 6, 1920.—According to this invention, a method of securing a metal electrode in the vitreous insulator of a sparking plug consists in screwing a metal cap on to the terminal end of the electrode, and in then spinning the wall of the cap, whilst on the insulator, to engage a portion thereof which is so shaped, for example, recessed, as to prevent the cap from moving in the direction of the longitudinal axis of the plug. The sparking-plug comprises a porcelain insulator A having a hole extending from end to end thereof, mounted in the usual manner in a metal body B, that has a lug B1 constituting the earthed electrode of the plug. The outer end C1 of the central electrode C is screw




threaded, and a metal cap D is firmly attached to it. The outer end of the insulator is provided with attachment means for the cap D in the form of a circumferential recess A1 and, as shown in Fig. 2, a longitudinal recess A2. The cap is prevented from turning about the longitudinal axis of the plug by having its wall forced, for example, by the blow of a hammer, into the recess A2, whereupon the wall of the thimble portion of the cap is spun into the recess A1. The cap is then held against movement in the direction of the longitudinal axis of the plug and also against rotational movement about the same axis, so that the central electrode is securely fixed in position in the plug. (*Sealed.*)

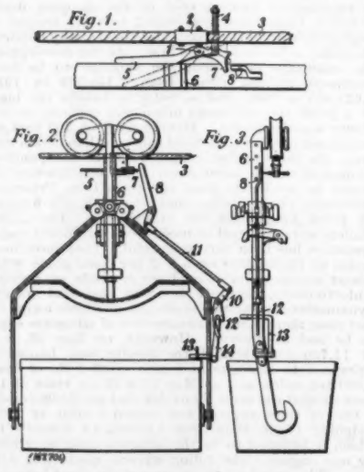
**167,642. R. and W. Hawthorn, Leslie and Co., Limited, Newcastle-on-Tyne, G. Paterson, Newcastle-on-Tyne, and C. Thew, Newcastle-on-Tyne. Oil Flow Indicator.** (3 *Figs.*) June 12, 1920.—This invention relates to oil indicators for gear-case sprayers of the type comprising a rotor in the path of the oil, the rotor being fitted to a spindle carrying a pointer visible through a transparent covering. The oil indicator, according to the invention, comprises a pipe section 4 to be traversed by



the oil, the pipe section being formed with an opening sealed by a glass bell or dome 6, a rotor 1 located in the pipe section so as to be propelled by the oil, a spindle 5 carrying the rotor and projecting into the bell or dome 6, a pointer 7 on the spindle exterior to the pipe section and out of the path of the oil. The bell or dome acts as an air vessel so that the oil does not rise therein and does not obscure the glass in any way to interfere with the observation of the pointer, which is free to revolve with the minimum resistance. (*Sealed.*)

### LIFTING AND HAULING APPLIANCES.

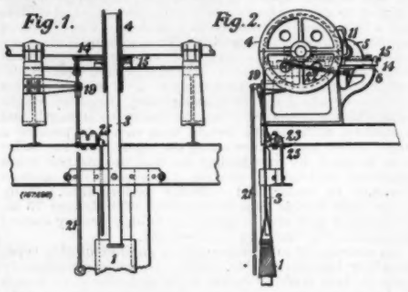
**167,701. M. Reid, Gartsherrie, Coatbridge. Overhead Ropeways.** (3 *Figs.*) October 2, 1920.—A device for tipping buckets on overhead ropeways comprises a two-armed lever pivotally mounted at 1 on a block 2 secured to the ropeway 3




and urged towards an inoperative position by a spring 4. One arm 5 of the lever presents a cam track arranged in the path of the bucket-carrying frame 6 and the other arm 7 is arranged as a striker clear of the frame 6 but adapted for engagement with a trip element 8 in the bucket-releasing mechanism. When the bucket approaches the tipping device, the arm 5 is engaged by the frame 6 and the arm 7 is brought into operative relationship with the trip element 8, whereby the bucket is tipped. The bucket-releasing mechanism comprises a lever 10 pivoted to the frame 6 and connected to the element 8 by a link 11, the lever 10 being provided with a slotted arm 12 engaging a latch-lever 13 pivoted to the frame 6 and engaging a latch pin 14. (*Sealed.*)

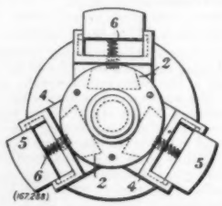
### MACHINE AND OTHER TOOLS, SHAFTING, &c.

**167,698. William Green and Co. (Eccliesfield), Limited, Eccliesfield, Sheffield, and W. P. Green, Eccliesfield, Sheffield. Drop-Hammers or Stamps.** (3 *Figs.*) September 11, 1920.—In a drop-stamp, according to the present invention, the roller-carrying yoke 11 is pivoted to a bracket 5 which is mounted, on the side of the pulley 4 remote from the tup 1, in guides 6 so as to be movable therein towards and away from the pulley axis. A lever 14 is fulcrummed adjacent to the bracket 5 and engages it by a pin and slot connection. The lever is moved about its fulcrum by an operating handle 21




through a bell crank lever 19 and a link. A spring acts to move the bracket away from the pulley. The tup 1 is raised by moving the rollers of the yoke 11 to press the belt 3 on to the periphery of the rotating pulley 4 on the side remote from the tup. Automatic release of the lifting device is effected by pivoting a rocking shaft 23 to a bracket on one of the tup guides with an arm 25 on the rocking shaft in the path of the ascending tup, and with another arm on the rocking shaft linked to the yoke bracket moving mechanism to withdraw the rollers from the pulley when the tup reaches a predetermined height. (*Sealed.*)

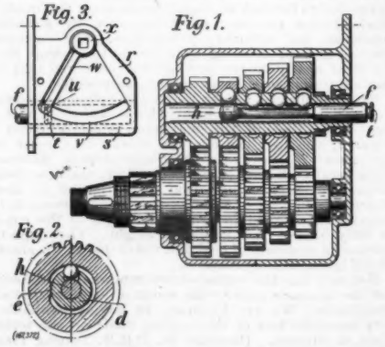
**167,288. J. R. Hobbs, Kensal Rise, London. Grinding Cylinders Internally.** (8 *Figs.*) May 5, 1920.—In a tool for grinding the internal surfaces of cylinders the radially-projecting spring-controlled grinding elements are held in removable cages, which have dovetailed members to engage with dovetailed grooves



in the external surface of the tool body. The improved tool comprises a central cylindrical body provided with dovetailed slots 2 arranged parallel to the axis and along the whole length of the cylinder. The dove-tailed slots house cages 4 adapted to receive a cutting stone 5 urged outwardly by springs 6. (*Sealed.*)

### MOTOR ROAD VEHICLES.

**167,372. G. A. Stafford, Birmingham, and Norton Motors, Limited, Birmingham. Variable Gearing.** (5 *Figs.*) July 12, 1920.—In constant-mesh gearing of the type in which a gear-actuating member *f* is made to slide in a hollow tubular driving or driven shaft *h*, an enlarged portion is adapted to force one or more intermediate ball or roller members outwards to key positively to the shaft any one of a series of pinions or sprockets mounted so as to rotate on it. Only one ball member is employed, according to this invention, to lock each pinion, and the recess *d* in the interior bearing surface




of the pinion is a circumferential groove which is interrupted at one point by a stop or abutment *e*, of small length circumferentially. By this means the change from one gear to another may be readily effected at any speed. The preferred means of operating the rod *f* is shown in Fig. 3, in which *r* is a casting bolted to the gear-box. A bush *s* is provided to house the outer end of the rod *f*. A groove *t* is formed adjacent to the end of the rod *f* and is engaged by a pin *u* working in an arcuate slot *v* and carried by a short lever *w*. The lever *w* is pivoted at *x* and is engaged by a gear lever. (*Sealed.*)